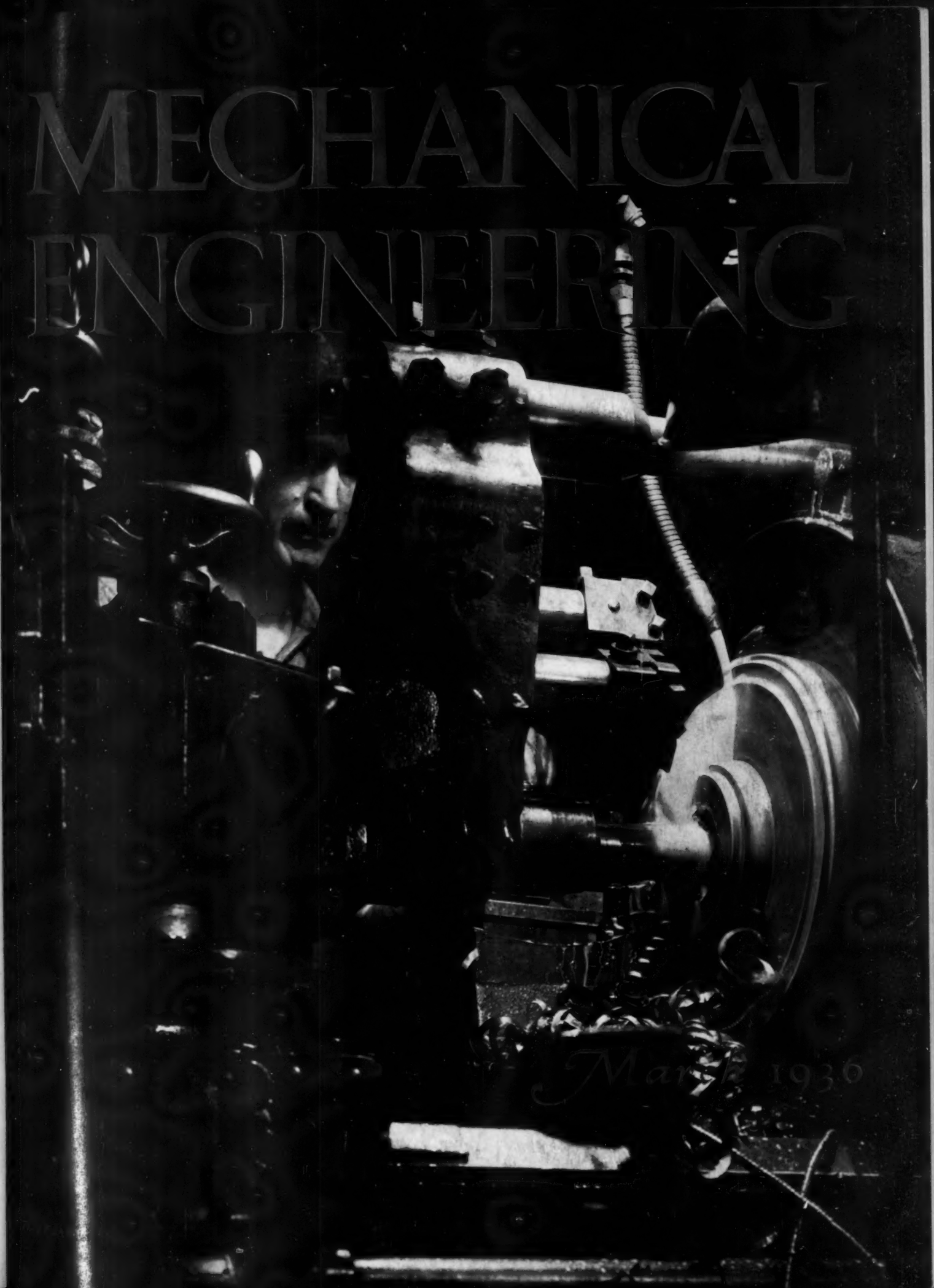
MECHANICAL ENGINEERING



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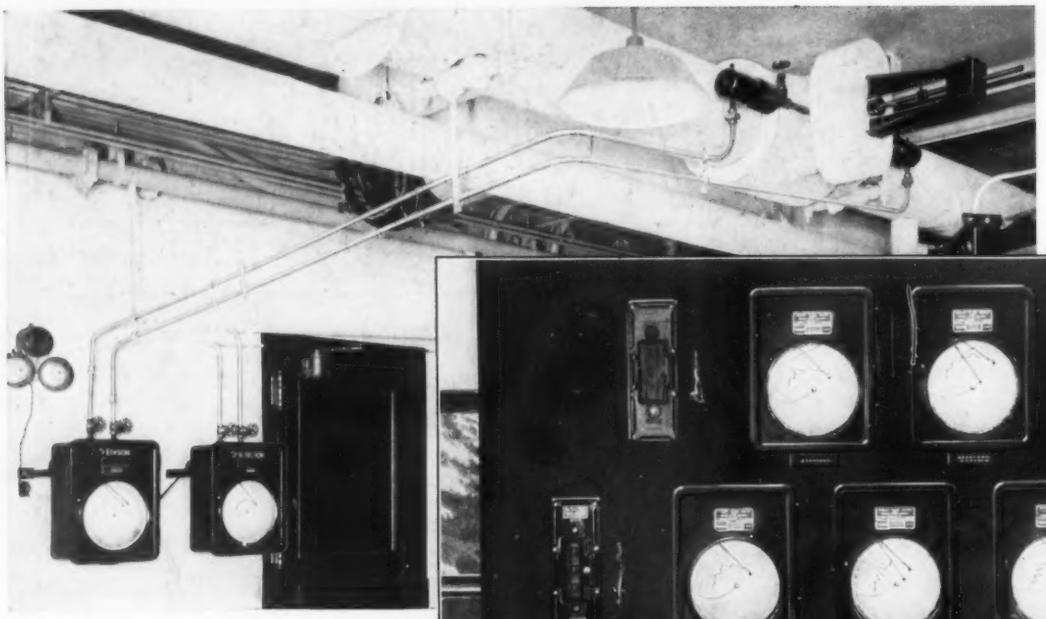
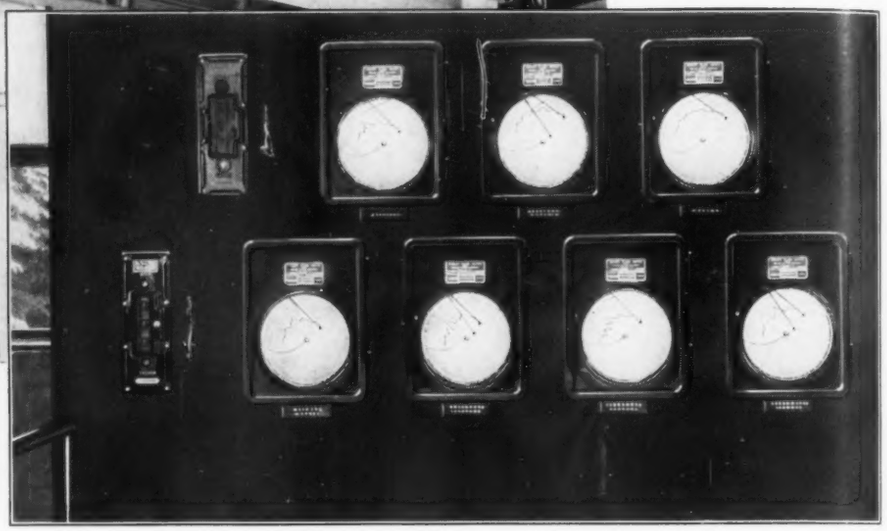


Bailey Adjustable Orifice in an 8" line measuring steam at 40 lbs. pressure.



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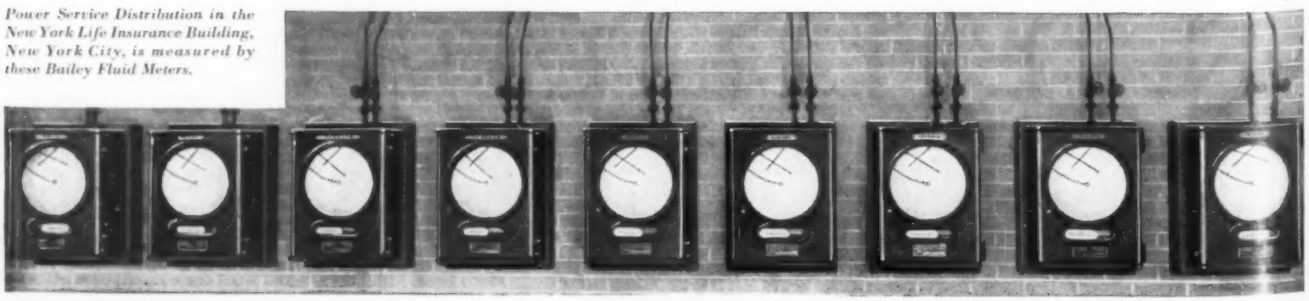

MECHANICAL ENGINEERING

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Contents for March, 1936

THE COVER . . . . . *Running a Turret Lathe*
SOCIAL SECURITY . . . . . *C. F. Hirshfeld* 145
OLIVER EVANS, 1755–1819 . . . . . *Greville Bathe* 149
AERIAL PHOTOGRAPHY . . . . . *B. B. Talley* 151
MILITARY AIRCRAFT ENGINES OF THE FUTURE . . . *F. L. Prescott* 157
THE A.S.M.E. MEMBER'S JOB 162
SEIZURE OF METALS AT ELEVATED TEMPERATURES 165
ALUMINUM CONNECTING RODS . . . . . *R. L. Templin* 169
USES AND LIMITATIONS OF RESPIRATORY PROTECTIVE EQUIPMENT . . . . . *Philip Drinker* 171
THE BROOKINGS REPORTS . . . . . *D. S. Tucker* 177
PRESIDENT'S PAGE 198

EDITORIAL 141
ENGINEERING PROGRESS 179
LETTERS AND COMMENT 189
REVIEWS OF BOOKS 195
BOOKS RECEIVED IN LIBRARY . . 196
WHAT'S GOING ON 199

DISPLAY ADVERTISEMENTS . . . 1
WHAT'S NEW 16
INDEX TO ADVERTISERS 38
PROFESSIONAL SERVICE 36
CLASSIFIED ADVERTISEMENTS . . 36

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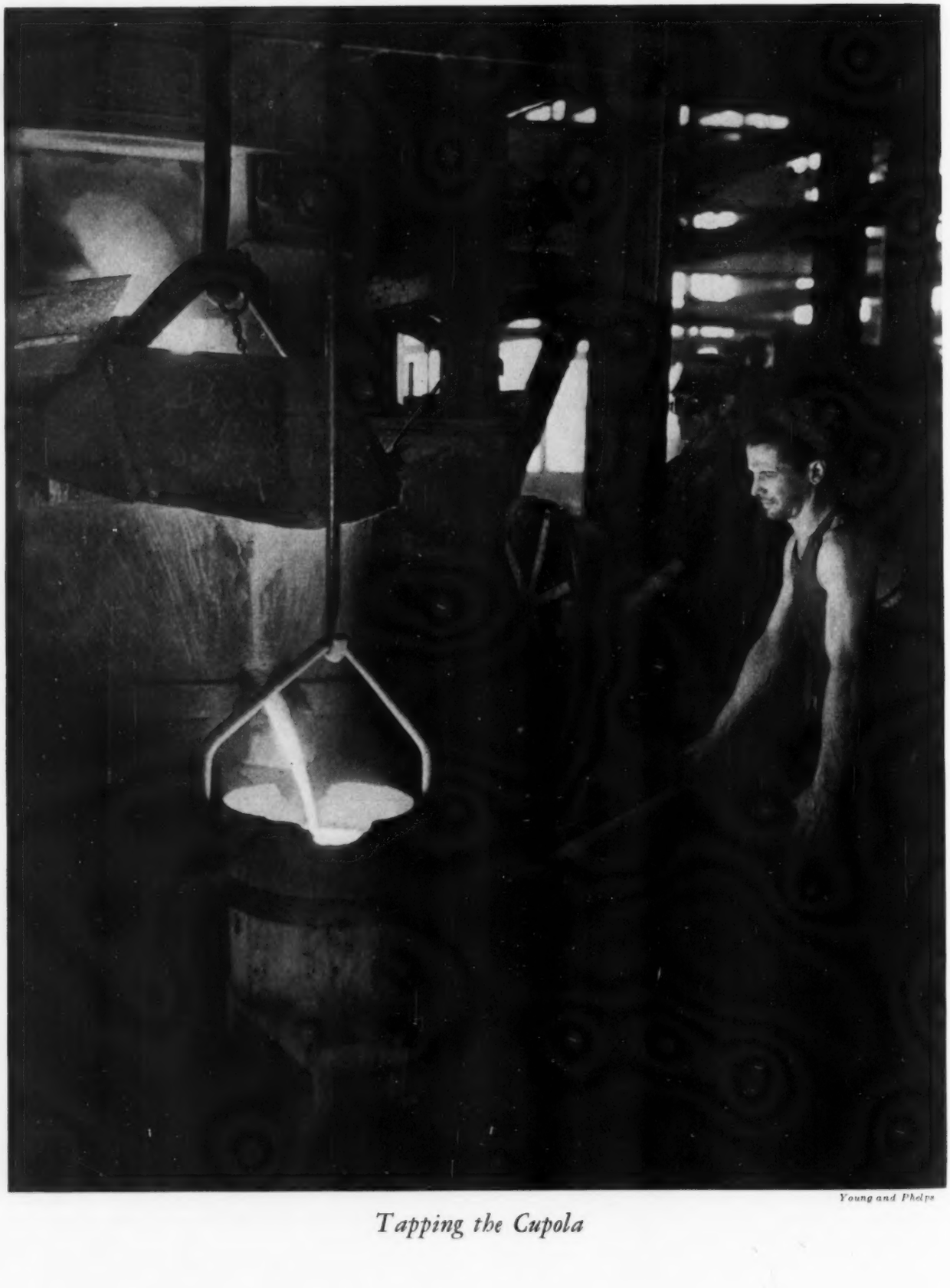

Young and Phelps

Tapping the Cupola

VOLUME 58
No. 3

MECHANICAL ENGINEERING

MARCH
1936

GEORGE A. STETSON, *Editor*

The President's Page

ON PAGE 198 of this issue W. L. Batt, president of The American Society of Mechanical Engineers, addresses the members of the Society in a new feature which has been called "The President's Page." This direct and personal appeal of the president is typical of Mr. Batt's methods. Those who know him—and before next December a considerable portion of the Society's members will have had an opportunity to meet him and hear him talk—are familiar with the penetrating frankness of his straight-forward manner. He is a believer in the personal approach, that man-to-man method which, undertaken by a master, inspires confidence because of its direct honesty.

As Mr. Batt explains this month, he is attempting to make up for his own inability to meet all of the demands upon his time and presence by assigning to his seven vice-presidents the responsibility of representing him in the seven recognized geographical areas into which the country, for purposes of local-section and student-branch organization, has been divided, and by means of a personal message month by month on "The President's Page."

This is a welcome and hopeful sign of vitality and sense of obligation in the high office of the president of the A.S.M.E. It calls for a reciprocal obligation on the part of members to utilize these media of communication that the president has set up in the interests of mutual understanding and greater Society achievement. Meet the president; if not personally then through his vice-presidents, and at least by means of "The President's Page."

Men and Machines at Hell Gate

THE officers and engineers of the New York Edison Company and the American Institute of Electrical Engineers are to be congratulated for the frank discussion of the recent disturbance at the Hell Gate plant on January 15 which brought so vividly to the consciousness of the citizens of New York their dependence on an uninterrupted supply of electrical energy. When nature destroys the evidence, as it did at Hell Gate, what happened is easier to describe than why it happened, and H. C. Forbes's statement at the recent A.I.E.E. meeting was concerned only with the former. In Mr. Forbes's statement, and in the incident itself, a number of important points stand out.

There is, for example, borne in upon us a sudden realization of the delicate balance of machinery, forces, and human directive control upon which life in a modern city depends and a demonstration of the discipline and skill of the men who make these technically complicated services normally so reliable. Candles have a pleasing effect on the dinner table, but no one thinks of using them for illumination until they are hawked at fifty cents a piece by enterprising shopkeepers in an emergency. We are, we realize in such moments, in "the hollow of the engineer's hand," as one editorial writer put it.

Then there was the tremendous destructive force of that enormous quantity of energy out of control and doing its damage in a fraction of a second—great quantities of heavy copper conductor completely disappearing by volatilization, an explosion wrecking parts of the building, and heat of such intensity as to burn away a considerable portion of concrete-covered steel work and iron reinforcing rods insulated from one another by the material in which they were set, as well as the damage to cables and switches, and to the wedges in the windings of one of the generators.

The sudden cutting off of energy from 360,000 kw of generators in Hell Gate and from the ties to other stations threw the system into disorder and placed a sudden and unexpected load on companion stations. In what seems an incredibly short time—from a few minutes in Westchester to an hour in the Bronx—service was normal, and only the sections of the network in Manhattan between 59th and 129th streets was more seriously affected.

Hudson Avenue picked up its share of the load, and Sherman Creek, already well loaded, found difficulty in keeping up steam owing to the drop in frequency on its electrical auxiliaries, which, it is said, fell as low as 40 cycles at times. Niagara Hudson power served to carry Westchester. Direct-current service, which carries 60 per cent of the load in the worst affected area in upper Manhattan, was uninterrupted; but the alternating-current service in this area, owing to the heavy connected load on the network, was only completely restored after several customer's switches were opened and the network subdivided, and with the total lapse of time from 4:16 p.m. to 2:30 a.m. Even at that it must be remembered that only 40,000 of the company's 2,000,000 customers were affected.

Commuters who rely upon the Eighth Avenue subway found themselves without their customary means of travel, not because there was no current to operate the

trains but because the signal system was tied in to the lighting circuits.

Mechanical difficulties were of minor significance. Boilers, turbines, and auxiliaries, in the hands of well-disciplined operators, suffered little or no damage and offered no extraordinary problems, as the effects of the disaster were principally confined to the electrical elements of the system.

No one can contemplate this disturbance or the potentialities of worse disaster without a feeling of satisfaction and admiration for the well-disciplined and competent operators upon whose shoulders fell the responsibility of thinking and acting quickly and correctly in a major emergency. From time to time tales of disaster on land and sea are spread over the pages of the newspapers, and where human weakness and incompetence add to the confusion and loss of life and property, bad enough as a result of natural causes, there is a sense of disappointment that men are not always equal to the emergencies they are fated to face. In one of his books William McFee tells of the heroic struggle of an engine-room crew to save a ship caught in the Indian Ocean with a broken propeller shaft that had punctured the hull. They were ordinary men, doing routine tasks, and completely unaware that they would suddenly be called upon to exercise every ounce of brawn and skill in fighting a tragic disaster. To their credit, as to the credit of the New York Edison Company's employees, they met the situation with intelligence and courage. Because of them we think better of mankind and hope, should it be we who are so tried, that we shall perform our own duties as well. Machines may fail, but men need not.

The Airship Report

SOME months ago attention was called (MECHANICAL ENGINEERING, March, 1935, pp. 179–180) to the Report of the Federal Aviation Commission, headed by Clark Howell, and presented on Jan. 22, 1935. Among its recommendations were six relating to lighter-than-air craft, one of which read: It should be the policy of the United States to undertake further construction and operation of rigid airships in naval and commercial service.

Three major airship disasters in this country had affected public opinion adversely to this recommendation prior to 1935; the *Roma*, which exploded while descending at Hampton, Va., Feb. 21, 1922; the *Shenandoah*, torn asunder by a thunderstorm over Ohio on Sept. 3, 1925; and the American built *Akron*, which came down at sea near Barnegat, N. J., April 4, 1934. Following the report the *Macon* was wrecked off the coast of California on Feb. 12, 1935. Tragic experiences of the British, French, and Italians with the dirigible had aroused public sentiment abroad to the point when further experiments with this type of ship were abandoned by these nations. The Germans alone can point to successful and safe airships, and these have been the product of a single establishment at Friedrichshafen. During the War, when conditions were as unfavorable as can be imagined, Zeppelin air raids over enemy territory darkened towns and put fear into the hearts of noncombatants, and since that time the phenomenal records made by the *Graf Zeppelin*, which completed a round-the-world flight in 1929, have added luster to the dark pages of airship history.

With smaller ships of another type the record in this country has not been so uniformly bad. Floating bags, used chiefly for advertising purposes, are a familiar sight over New York, and within the month one engaged in an errand of mercy to bring food to the isolated inhabitants of Tangier Island, only 90 miles from Washington, when severe winter weather cut off all but aerial routes to its shores.

A report of another character, relating to airship construction, and made on January 26, 1936, to the Secretary of the Navy by a special Science Advisory Board, expressed the unanimous opinion that "the best interests of the services in which airships give promise of useful and effective service, both commercial and naval, require a continuing program of construction and use." Based on this opinion it was recommended "that the Navy department should continue with a positive, carefully considered program of airship construction." The report further recommends "that the first large airship built . . . be considered not an adjunct to the fleet but rather a flying laboratory or flying training ship, not only for extensive technical observations of the structure under operating conditions, but also for enlarging our knowledge regarding the best conditions of service for such vessels, and, as well, for giving opportunity for the training of officers and crew in the technique of handling airships under all conditions of weather and service."

These recommendations seem sound and admirable. They are based on the uncontestable fact that the Germans have met with success in construction and operation of airships. They recognize that aerodynamic and structural knowledge has made noteworthy advances, and that engineers and operators in this country, in spite of the grim record of the past, should be able to perfect their techniques to equal, if not to surpass, those of the Germans. Instead of closing the door, with a gesture of despair, on a type of vessel that may have useful characteristics in military and commercial services, they leap the psychological barrier and accept a challenge to man's ingenuity and persistence. It was not the purpose of the Science Advisory Committee to pass judgment on the economic or military value of the airship. The report was directed to "the basic question of the practicability of the design, construction, and operation of airships with a reasonable assurance of their safety and reliability, and with such technical characteristics as to offer good promise of potential usefulness either for commercial or military use." The recommendations are the first answer to this question; and the spirit of the scientific approach is admirably demonstrated in the suggestion that the ships, if constructed,

be devoted first to the ends of scientific research. It is hard to quarrel with this judgment.

Members of The American Society of Mechanical Engineers will be gratified to know that the Science Advisory Committee was made up largely of experts from within their own membership, ably headed by William F. Durand, past-president of the Society, John Fritz Medalist, and recognized authority on aeronautical science.

Engineers and Philosophy

JOSIAH ROYCE, that great teacher and proponent of idealistic philosophy at Harvard a generation ago, whom President Roosevelt called to memory in a quotation with which he ended his famous speech to Congress on the state of the nation, wrote, more than forty years ago, "The worst tragedy of the world is the tragedy of the brute chance to which everything spiritual seems to be subject among us." He might have added "physical," as well as "spiritual;" yet how tragic physical chance may be we cannot be so certain. Of it our modern physicists have written much in developing, as they have been doing, Heisenberg's "principle of uncertainty."

Royce the idealist, as this one quotation will show, was not blind to the realities. He had wrestled with two scientific principals that others evaded, or denounced, or failed to comprehend; and his manner of reconciling the principles of evolution and the second law of thermodynamics, the famous "heat death" of his generation—Henry Adams thought them mutually contradictory—are not easily followed by the lay mind. But he faced these problems squarely, as a searcher after truth must indeed do, and reconciled them to his philosophy. So notable an achievement draws attention to the hazards that are put in the way of efforts at human understanding of ultimate truth by discoveries made in science.

Royce lived in a "hard" age, for deterministic interpretations of physical science put a heavy strain on the faith of men in the freedom of the will. It was a time at which the realistic swing of the philosophic pendulum was in full momentum, a time of neat and simple physical laws which bred cynics and materialists. What the intellectual world had lost by throwing over Pythagoras and Democritus and casting its lot with Plato began to come back with the honest doubts of Galileo, and passed through recurrent phases of realism and idealism with amplitudes made more divergent by men like Newton and Hume on the one hand, and others like Spinoza and Berkeley on the other. And as science grew, and the authority of the church waned, the principles of evolution and the second law of thermodynamics seemed to deal mortal blows during the nineteenth century. Many of us are too young to remember the mental agonies they caused men to suffer.

Today we are not so sure. Science itself has cast confusion over the die-hard deterministic, and men like Eddington, Jeans, Smuts, Heisenberg, and Schrödinger, and Compton and Millikan in this country, have been pointing to flaws in the tight systems of the nineties and opening up fresh fields of speculation and new views of truth that do much to reconcile the apparent contradictions. Take Schrödinger, for example, disciple of the principle of uncertainty, who, in his excellent little book, "Science and the Human Temperament," says: "The old links between philosophy and physical science, after having been temporarily frayed, are being more closely renewed. The farther physical science progresses, the less can it dispense with philosophical criticism;" and his conclusion that "the assertion of determinism is certainly possible, yet by no means necessary, and when more closely examined not at all very probable."

Or turn if you like to Arthur H. Compton's Terry lectures at Yale University, done into book form in "The Freedom of Man," and see how, in a physical experiment, the interposition of an intelligence can choose the photon that will blow the world to bits or shut down the diabolical machine concocted to this end. These are important matters for intelligent engineers to ponder, and Compton's book is one to aid their thinking.

In the preface to his book Compton sets forth this principle: "I consider it the scientist's clear duty to the society which makes possible his investigations to report his findings to that society in a form that can be understood, together with an effort to show their import in so far as they would seem to affect human life." This is a clear acknowledgment by a man of scientific learning, a Nobel prize winner in physics, that such as he have obligations to the rest of us that do not cease with discoveries that may disturb our lives and vision of the truth. It is an important admission, and a grave responsibility.

Any one reading C. F. Hirshfeld's provocative paper in this issue will come to the conclusion that Hirshfeld accepts Compton's sense of obligation and applies it to the relations of engineering to society. It is all very well for scientists and engineers to content themselves with being competent technicians. This is a worthy and useful achievement. But he who puts in the way of a Royce such intellectual hazards as the principles of evolution and the second law of thermodynamics ought to help him to fight his way through the perplexities involved. (What light Royce might have found in the principle of uncertainty to brighten the tragedy of brute chance, had he been able to talk with Heisenberg, none can say.) And so engineers, foisting upon the world, for its betterment let us admit, new mechanisms involving disorders in social and economic control that affect profoundly the lives of uncomprehending men, can scarcely evade some measure of responsibility in seeking solutions. Perhaps the engineering profession as such is incompetent to develop a philosophy of social welfare. But at least there are individuals in the profession who can assist in such an undertaking, just as Compton has tried to guide those perplexed on the subject of the freedom of man.

Fred Low

IT MAY be trite to say of Fred Low that "he had the common touch," yet the phrase so aptly sums up his unusual human qualities that its use will be pardoned because it will be understood by all who knew him. The circle of his friends and of the readers of the magazine he edited for 42 years was so broad that none can estimate the extent and value of his services to those honest, competent men who spend their lives with the generation of power. To hundreds of ambitious engineers he was a schoolmaster as well as a friend, for from his magazine they got that educational sustenance that aided their growth. As a clearing house of the everyday practical experiences of those who maintain and operate the machinery that keeps plants running and serves the production departments and mechanical features of institutions and buildings, he enlarged men's competence and skill and prepared them not only for advancement and more responsible posts, but for the emergencies that are so vital a factor in the successful performance of responsible duties. He opened the minds of these men to a keener appreciation of their duties, and provided them with the knowledge of rapidly advancing techniques that come with new machinery, devices for greater economy, and the introduction of novel elements in which they had neither experience nor fundamental training.

The period his work covered witnessed the introduction of high-speed engines and turbines; of electrical dynamos, electrical motors, and hundreds of electrical devices; of stoker and pulverized-coal firing; of oil fuels and gas engines; of high-pressure boilers, economizers, feedwater treatment, increasingly higher pressures, superheaters, and air heaters, to mention but a few. As these new elements were developed, Fred Low brought to his readers, in a way they could comprehend and put into practice, the essential information by means of which the man could advance with his art. And side by side with these more technical contributions were his wise council and kindly philosophy, which steadied the judgment, stiffened the backbone, and fanned into flame the latent pride of craft that warms the hearts of all true men. Here is a memorial, alive in the successes of hundreds of individuals, of which any man may be proud and in which all engineers can take a keen delight.

Nor are these faithful tenders of fire and steam, of machinery and electricity, his only beneficiaries. Men in responsible positions in the largest public-utility power plants read his paper. Designers, draftsmen, and machinery manufacturers also learned in his school. His city honored him because of his loyal services; and The American Society of Mechanical Engineers leaned heavily upon him for tasks that he could do better than any one else. His long service as chairman of the Boiler Code Committee and the Power Test Codes Committee are evidence enough of the esteem in which his fellow engineers held him; and the high office of president of the Society was but a meager honor with which to repay the patience, tact, knowledge of men and machines, and long hours of uncompensated service that he contributed to the Society and the profession.

One of his lesser known contributions to his Society was to increase the dignity and formal conduct of technical sessions. Those who were privileged to attend the authors' breakfasts and luncheons which preceded the technical sessions of A.S.M.E. meetings during his presidency will recall the emphasis he laid, in delivering his instructions to the chairmen who were to preside, on the importance of their task, and the simple dignity with which he invested this temporary assignment of his own office to them in handling them the gavels, symbols of their own authority, with the charge that they were to be used with kindness, firmness, and intelligence; saying that the curtains had been drawn aside and the world was looking in upon the manner in which the Society conducted its professional business.

No one can explain the ways of Providence that compel a just and good man to end a useful life on a bed of pain. Fred Low bore his affliction with what grim courage a long life in contact with realities taught him—bore it with the added courage that a brave and devoted wife brought daily to his bedside. As in his active life, his mind and interests were with the friends he had known and the work in which he was no longer permitted to engage. Power had been his life; the spiritual attributes of power had made their mark upon him.

The Perfect Gadget

WHAT to do about automobile accidents has engaged the attention of many persons. One state governor, thinking the trouble lies with machine maintenance, is for examination of motor cars. A legislator would insist on a periodic examination of drivers. A motor-vehicle commissioner is talking seriously about speed-control governors; and automobile manufacturers are preaching safe and sane driving.

It all recalls a story told by Dean Kimball when he presented his paper on the steam engine in the nineteenth century at the Watt Bicentenary at Lehigh last January. The story, unfortunately omitted from the text we published last month, is about a great giant of an Irishman who went to the Union Iron Works to test, inspect, and accept for the mine one of those hoisting engines Dean Kimball wrote about so appreciatively. According to the specifications, automatic safety devices were provided that would take the controls out of the hands of the hoist engineer and shut down and brake the engine in case the operator let the cage run out too high. The devices were well designed and operated perfectly. Obviously, the inspector was well pleased with his many trials of their functioning. "Well," he said at last, "now if you would only put in a steam-operated boot that would kick the engineer off his seat if he ever ran the hoist so the safeties would have to operate, it would be perfect." The perfect gadget for automobile traffic control would whisk the offender's car off the road and land him in a psychopathic ward, instanter.

SOCIAL SECURITY

Should the Engineering Profession Formulate Its Philosophy?

By C. F. HIRSHFELD

DETROIT EDISON COMPANY, DETROIT, MICHIGAN

IN THESE DAYS of loose speech, magnificent gestures and promises, groundless enthusiasms, slogans, and isms, it is well to define what one means by terms used in an address. This is particularly true when the speaker, as in the present case, is an engineer and is expected to demonstrate a certain exactness in thought and expression not demanded, for example, of the politician.

The terms "social welfare" and "social security" have been given a somewhat specific meaning by the Federal Government during the past few years and particularly by certain legislation enacted during the last session of the Congress. I would have you understand that I do not propose to use these expressions in any such narrow and specific sense. I am not going to use one or the other as a group title for unemployment insurance and old-age pensions. And I shall not employ them with specific reference to the engineer. I shall use them to cover a multitude of aspirations, efforts, and accomplishments evident, in one form or another, throughout a large part of the civilized world and having for their objective the general improvement of the social and economic status of the great mass of humanity. Admittedly, this is a broad subject, but as I see it, we must attack all social problems in a broad way first, trusting that out of the broader consideration we can draw such light as may be necessary to guide us in more detailed attack.

SOCIAL WELFARE A RECOGNIZED MOVEMENT

We may well start by recognizing that for several centuries, at least, there has been evident a very general movement toward improving the lot of the less favored members of our populations. During the past few decades the movement has been both broadened and accelerated. Some of these endeavors are now of such long standing that we take them for granted and no longer think of their significance. It may help to enumerate one or two of these.

Universal education, as practiced in this country and to some extent in other countries, serves as an excellent example. We have come to regard the education of all children up to a certain age or up to a certain degree of attainment as a proper public charge, to be paid for out of taxes. In this country we justify it most commonly by saying we must have educated voters in a democracy. I believe it far more accurate to regard it as but one of the many things we do to afford as nearly as possible an equal opportunity to all. To me, public education is a social-security device in that it tends better to fit individuals to provide for the social and economic security of themselves and their dependents.

Again, we have all sorts of free nursing, medical service, and and hospitalization. No longer do we permit the unenlightened to stew in their own juices; now we regard it as incumbent upon the taxpayer to provide to some extent in these ways for his less fortunate brethren.

In both instances the public not only pays, but the public, through its laws, insists that the opportunities it provides shall be availed of. In this country you may not say that your child shall work instead of going to school. The public says it shall go to school, within certain limits set by the laws of the individual states. You may not say that your children's teeth shall be allowed to take care of themselves. No, the public provides dentists to inspect and, if necessary, to operate.

An example of a slightly different type, but equally mandatory, is furnished by workmen's compensation laws. These protect the wage earner against the supposedly unsympathetic employer by stating specifically what form and amount of compensation shall be paid the incapacitated and the disabled, and by providing that it shall be paid. And again the public pays, because it is obvious that compensation payments form part of the cost of doing business and thus determine to that extent the cost of articles produced or services rendered.

I might go on at length and cite for you example after example. I hardly believe this to be necessary. You are an educated and a thinking lot and you can recall many examples for yourselves. The essential point is that as we have built up what we call our civilization we have developed more and more acutely a social consciousness; one might almost say a social conscience. And as we have done this we have enacted successive laws intended to produce what, in a gross way, we may speak of as greater social security for the underprivileged. In all cases costs are paid directly or indirectly by the mass of the population, and in most cases the body politic removes to greater or lesser extent the privilege of personal choice.

THE ENGINEERING APPROACH

Turning now on to a different tack for a minute, let me ask you, What does an engineering type of brain do when it observes that water, left to its own devices, seems always to run down hill? Or that a certain amount of heat put into a heat engine produces, with the aid of that engine, only a fractional part of itself in the form of usable mechanical energy? Or any one of the numerous other natural phenomena with which this type of brain concerns itself? It endeavors to reduce its observations to some sort of rationalization which will enable it to predict performance in other cases. Please note that in doing this the engineer does nothing more than record and interpret experience. In simple language, he finds that under such and such conditions something has been observed to happen in a particular way. He assumes, from experience, that under exactly the same conditions the same thing will always happen in the same way. He dresses this up in high-sounding verbiage or in the more imposing symbolism of mathematics and calls it natural law.

Now if the engineer observes that social organization provides, one after another, laws and instrumentalities leading more and more in one direction, is there any reason why he should not conclude that this phenomenon represents the action of some law of this particular social structure? Is there any reason why he should not assume that as a result of the operation of this law the movement will continue at least so long

An address before Section M (Engineering) at a meeting, St. Louis, Mo., January 3, 1936, of The American Association for the Advancement of Science.

Robert Dudley Smith

as the controlling factors, whatever they may be, remain unchanged? I believe there is not. I think we are safe in assuming that, even though we do not know the reason why or the *modus operandi*, there is in existence some force continuously driving toward greater social security for the individual, with particular reference to the less favored individuals.

As engineers it may worry us to accept such a conclusion when we do not understand the mechanism. I suggest that you ask yourself how much we really know about the mechanism of gravity and its action, or of the transmission through space of various radiations, before you waste much mental energy in worrying over accepting a social phenomenon as such because of ignorance of its motivation.

An engineer engaged in a study of this movement will realize quickly that a common and outstanding characteristic of all these devices for increasing social security is that they cost money. In the early years of these endeavors the money was frankly obtained by taxation. More recently there has been evident a tendency to disguise the source, to set up scenery which seems to indicate that the most fortunate are in some way compelled to provide for the least fortunate. There has also been widely preached a theory that it is possible to control the ultimate incidence of taxation by proper choice in the initial collection. No engineer who is worthy of the name can be fooled for any great length of time by such irrational theories.

Irrespective of how the process may be disguised, the sums used for such purposes by government itself, as well as all other sums expended by government, must be derived in the long run either from the confiscation of part of the current labor of the people of the nation or from the hypothecation of future labor; i.e., taxes at the present time, or borrowing of sums to be collected as taxes in the future. It is equally true that, irrespective of the efforts made to disguise the fact, attempts to finance through collections from employers or other supposedly favored individuals must, in the long run, end in collections from the mass; that is, further confiscation of labor. All these charges ultimately become part of the cost of doing business and are collected from the buyer in the price of the article sold or service rendered.

If these generalizations are true, it would appear that as the years have gone by we have found ways and means of confiscating greater and greater amounts from the labor of our people. This must be so because we have spent proportionately more and more upon social-welfare devices, without spending compensatingly less upon other things. Moreover, I believe it can be shown that in the long run this has not been done entirely through borrowing against future labor. How then has this thing been possible?

I can see but one answer. It is that the engineer and people closely akin to him have provided, one after another, facilities and mechanisms which in the grand interplay of national and international industry and commerce have made it possible to extract ever-growing sums for new social activities of the type here under discussion. I would call your attention particularly to the fact that, even so, the actual real net wages of workers have increased almost continuously during the same period. If this were not so we could not have workmen of the present day working eight hours instead of ten, twelve, and more, and at the same time living in better homes than did their fathers; owning automobiles, radios, washing machines, and electrical refrigerators where their fathers were put to it to provide a roof over bare rooms, meager sustenance, and the poorest of clothing to cover the backs of their children.

TIME FOR ENGINEERS TO APPLY METHOD TO SOCIAL PROBLEMS

If this explanation is correct, or is only partly correct, the engineer may well be proud of this achievement. But I do not believe he can longer be content only to produce and to operate those technical improvements which, according to my analysis, have made advances in social welfare economically possible. I think it is high time he began to apply his factual method of attack to some of the social and economic problems that his works have either brought into existence or made possible of existence.

In some respects we have reached the place where we are in the position of the small boy confronted with a table overloaded with edible goodies. We may be so confused that we spend our time in looking instead of in eating. We may, on the other hand, ignore those things both most tasty and most digestible because we are attracted by the appearance of something much less so. Or we may gourmandize to our own future discomfort if not to our actual undoing. In the words of today, we have shifted from an economy of scarcity to a condition at least approaching one of plenty. We are confronted with new problems in attempting to utilize the unexpected abundance. And with the curious perversity of human nature we frequently blame the presence of abundance for certain of our difficulties instead of blaming ourselves for our failure to develop ways and means of utilizing it properly. Remember the small boy I have just mentioned.

Some few engineers throughout the world have begun to give serious thought to the social and economic import of their

works. Those who are honest admit frankly that they find themselves greatly at a loss when they enter this field of endeavor. They miss the stationary landmarks, the carefully marked roads, and the topographical maps with which they are so familiar in their more accustomed fields. They find themselves in a land with the dimmest of trails or no trails at all; a land inhabited by all-powerful gods with good and bad dispositions whose characteristics have been handed down from father to son in the form of tradition and folklore; a land in which a single word, such as wages, wealth, value, rent, interest, and many others may have one meaning today or in the mouth of one man and a different meaning tomorrow or in the mouth of another. To the engineer, with his penchant for exactness of thought and expression and for factual attack upon problems, this chimerical land is indeed a nightmare.

But, if I mistake not, it is now time for the engineer to educate himself for work in this strange country. It is to my mind necessary that he assist in the charting of its landscape; that he help to lay the demons and to find and cultivate the benevolently inclined spirits and deities; that he lend a hand to the interpretation of its traditions and customs and assist in the formulation of proper laws consistent therewith.

I think the engineer would very shortly point out and prove certain important facts which appear either to have gone unnoticed or to have been insufficiently appraised. I cannot myself claim proficiency in the exploration of this strange land, but such brief excursions as I have been able to make into it have already opened my eyes to certain interesting things which may possibly be facts of importance.

Galloway

DOES MACHINERY INCREASE UNEMPLOYMENT?

For example, I have known for some time that many of the people resident in it have proved to their own satisfaction that the work of the engineer in the designing and building of so-called production equipment has resulted in permanent unemployment of huge masses of people. And yet, very cursory excursions into this, to me, new country have shown me two things which lead me to wonder whether this is so.

For one thing, I note that the carefully garnered statistics of our nation appear to show that, during the period in which the devising and using of production equipment and methods has occurred with the greatest rapidity and to the greatest extent, the following have contemporaneously occurred:

(1) The population of our country has doubled
(2) The percentage of people in our country who are gainfully employed has increased steadily
(3) The number of people engaged in agriculture has very steadily decreased; and
(4) The wages of those gainfully employed have steadily increased.

Somehow, I cannot make these statistical facts fit with the theories which seem to be most popularly held in the strange land I have been speaking of.

And again, these same national records show that our economic history has been a series of ups and downs. And the contemporary literature shows that at each time of depression we have discovered the existence of the pernicious disease now known as technological unemployment. However, each time that the economic conditions have improved, this terrible and incurable disease has either vanished from our midst or has had such meager and scattered incidence as to have gone unnoticed.

I do not know that these hastily made observations in this queer land are worth the time it has taken me to tell them. But I do know that if a properly equipped group of engineers will undertake a survey they will produce facts and maps of great and probably lasting value.

SOME BENEFITTED, OTHERS HURT

I think I have discovered another strange thing during my cursory excursions. I believe that not only does the individual give up a certain degree of personal liberty each time a new form of social security is made available, but also that many individuals who were to have been benefited thereby are irretrievably hurt. Perhaps one of the best examples I can cite is furnished by unemployment in the older age brackets.

In the curious land I speak of much is said these days about the bitter plight of men above forty, or forty-five, or fifty. It is said that industrial magnates will not employ them because of their inability to maintain the grueling pace of modern industry. I am not an industrial magnate but I am fairly well steeped in industry. I cannot imagine an employer who would not welcome the greater skill and greater stability and reliability of middle-aged heads of families and home owners if they could utilize such without more than compensating disadvantages. And, I cannot reconcile the supposed inability of these older men with the very remarkable performances they gave under much more severe conditions through many more hours per day in earlier generations.

I think I have observed that each time workmen's compensa-

tion laws have been enacted and each time they have been made more stringent and have attempted to give the employee greater benefits at the expense of the employer, the employee has suffered in several ways. And not the least of these has been the growing elimination of the older men and of the less well physically endowed on the assumption that, in an actuarial sense, they were poorer risks. Is it possible that the very laws which were enacted for the protection of wage earners, for the purpose of giving them greater security, are responsible, in whole or in part, for the reported increasing difficulties of men beyond a certain age? It seems possible, and the possibility might warrant thorough investigation.

In a more general sense, is it possible that there is a force or group of forces acting in our social structure which inevitably produces hardship for at least some of those that our efforts toward increased social security for the individual are supposed to benefit? I suspect that there is. Certainly, a factual type of attack of the kind the engineer is accustomed to should enable us to answer this question.

IS SOCIAL SECURITY SAFE FOR SOCIETY?

As I have wandered in this land so familiar to sociologists and economists and so strange to engineers I have begun to wonder about another and perhaps a still bigger subject. Is social security safe for society? Let us explore this question superficially.

As medical science and practice have advanced we have learned to carry to maturity more and more of the infants that in earlier generations would have died because of poor physical endowment. Is this process causing a gradual physical deterioration of the race? Many learned men particularly proficient in this field claim it is. As I read their arguments through an engineer's eyes I do not believe they prove their case, but certainly there is such a possibility.

Again, through various social-welfare devices we now safeguard the numerous progeny of the mentally deficient who would otherwise not survive or would not survive in such great numbers. Are we thus jeopardizing the mental and moral fiber of our people? Many scholars versed in problems of this type say we are.

Carrying the matter further, we now envisage devices which will protect people against unemployment and the economic vicissitudes of old age. Is it possible that by thus lessening the risk to some and lessening the discipline of others who in previous ages supported unemployed and aged relatives we are in some subtle way undermining self-reliance, initiative, ambition, and other vague but nevertheless real and supposedly desirable characteristics of individuals? Many experts say we are. One must at least admit the possibility of such things being so.

SOCIAL BETTERMENT OPPOSED TO METHODS OF NATURE

In a very general way I think we should recognize that much of what we have been doing toward social betterment has been absolutely opposed to the methods used by Nature. With respect to living organisms she seems to operate in a very unsympathetic and rigorous fashion. Only the best endowed survive, and only then when they work effectively to insure survival. It is spoken of as the survival of the fittest. We now appear to be engaged in grandiose attempts to set at naught this apparently general rule, at least in so far as human beings are concerned. Is it safe to do so? Are we going to end as a collection of soft and irresponsible individuals mixed with a collection of gibbering idiots? Who can say?

Undoubtedly, you have heard it said that democracy carries within itself the seeds of its own dissolution. I think this is true of every form of human organization and for the reason that it must be made up of humans. If one may judge from the teachings of history, it seems that so long as the members of these organizations cooperate reasonably wisely and reasonably carefully toward worth-while ends, the organizations are of value and survive. But when too much of the collective effort is dissipated in selfish pursuits and in other socially undesirable directions the virility appears to flow out of the organization and it passes ultimately into the category of things that have been.

Viewed in this way I think it is as yet impossible to say whether social welfare is safe for society. One's desire is to answer the question in the affirmative. Sentiment, compassion, and all the other qualities that we are accustomed to regard as virtuous argue in that direction. But, are these qualities safe guides? When such characteristics cause us to parole dangerous criminals before they have completed their terms and when this results in almost immediate return to crime we are apt to conclude that sympathy for such unfortunates is not a safe guide. Possibly the same thing may be true with respect to these larger tendencies and movements that I have grouped under the grand title, "social security." Certainly, no one can appraise them now with the meager factual data available for such purposes.

This rather rambling discourse may show you the trend of my thoughts with respect to this large question. More important, it may serve to incite in you a curiosity to explore on your own account the strange but interesting land I have spoken of. Certainly, it should convince you that it promises the explorer who wishes to enter it many interesting and worthwhile adventures.

I was asked to speak on the subject, "Should the engineer formulate a philosophy of social welfare?" My own feeling is that he must, largely for reasons which I have foreshadowed in what I have already said to you.

THE ENGINEER CAN ASSIST IN SOCIAL WELFARE

In my interpretation it is the engineer who, for good or bad, has made the continued enlargement of social-welfare programs economically possible. But he has had little to do with the development of such programs nor has he even thought it necessary, in many cases, to study their present effects and ultimate tendencies. I cannot prove that the engineer can assist greatly by studying these presently nontechnical subjects, but I firmly believe he can; and I firmly believe that therefore he must. His method of attack has been fruitful in other fields; in fact in all in which it has been used properly. There is at least a reasonable chance that it will prove equally usable and useful in this field. Certainly, it is the engineer who has produced many of the current problems through providing the means by which they have been created or amplified. To me, equally certainly, he should address himself to the doing of his part in the solution of them.

If he is to do this and if he remain an engineer in mind and spirit, he must of necessity develop a philosophy of social welfare. This is in fact his method of attack. This is his rationalization of observed and discovered facts. This is the way in which he differs from most of his fellow men in this complex civilization of ours. And it is in this difference that there lies the hope that he may be able to offer assistance of real and lasting value. Proved fact must be more powerful than unsupported opinion in the hands of otherwise equally well-equipped individuals. Determine all the facts about a problem and the problem ceases to be. Determine all the facts about social welfare and social welfare ceases to be a problem.

OLIVER EVANS, 1755-1819

An Early American Inventor and Engineer Whose Biography Has Recently Been Completed

By GREVILLE BATHE

PHILADELPHIA, PA.

I THINK it can be said without fear of contradiction that while the name of Oliver Evans, the inventor and early steam engineer, is familiar to the many both in his own country and also in Europe, it has been his fate never to have had a biographer who did much more than praise his genius.

Eulogies of great men are always disheartening things to read, for even the greatest of men is but human and it is this human quality in prominent people that should be recorded, rather than a few selected triumphs of their lives.

The real personality of the long-since departed can best be gaged by what they have written in their own hands, but it is only too true, unfortunately, that with the passage of time the various guardians of these old documents neglect to provide for their safe and permanent keeping and thus many links with the past are broken and become lost to posterity, sometimes by the slender margin of a few years.

OLIVER EVANS

(From the frontispiece of "Oliver Evans," by Greville and Dorothy Bathe.)

In the course of my investigations into the life of Oliver Evans,[1] I have on several occasions been told with regret that if I had conducted my inquiries some few years earlier, this or that letter or document would still have been available.

A particularly unhappy case of this kind was the loss of the business ledgers of the Mars Works, which was Oliver Evans' engineering establishment from 1806 to 1819. Several of these ledgers were in existence up to a few years ago, having been in the possession of a direct descendant of Sarah Woods, the youngest daughter of Oliver Evans. But after a recent thorough search by the family, these priceless books cannot now be found, although they had safely survived more than 100 years.

On occasions I have been asked what it was that first awakened my interest in Oliver Evans to the extent of devoting so much time to him. This question is difficult to answer with any one plain statement. Perhaps my work of constructing historical models, principally of steam engines, engendered a study and an accumulation of general information about all the early engineers, of which Evans was one.

Some twenty years ago there came into my possession a book published in England in 1827 which included a wood engraving of Oliver Evans' grasshopper steam engine. However, the name of Oliver Evans did not mean much to me at that time. About three years ago there appeared in the Philadelphia *Evening Bulletin* an advertisement illustrating Evans' "Orukter Amphibolos," that strange machine, half dredge and half automobile. Upon seeing this, I began to wonder if such a contraption really had existed, and if so, how it could have functioned as depicted. From this small germ of thought, my curiosity was aroused and I was drawn into the fascinating game of history hunting in which Oliver Evans was my quarry.

On the collection of historical data concerning Evans, it would be well to touch briefly. I may say that it has been my happy lot to have had the fullest cooperation from nearly all to whom I have applied for information, but in the begin-

[1] These investigations resulted in a biography, "Oliver Evans, a Chronicle of Early American Engineering," by Greville and Dorothy Bathe, published by the Historical Society of Pennsylvania, Philadelphia, Pa., 1935.—EDITOR.

Presented at a meeting, Philadelphia, Pa., October 10, 1935, of American Members of The Newcomen Society of England.

ning, the real difficulty was to decide whom to approach as being the most likely to have any original knowledge to impart about our subject. My first year of investigation, which was in 1933, was of a haphazard nature, consisting principally of reading everything that other writers had published about Evans since the time of his death, without realizing that by compiling a book from such sources I would probably be only perpetuating many inaccuracies. This fact, however, was amply borne out by subsequent knowledge acquired from more reliable informants.

SEARCHES IN ENGLAND AND AMERICA

By the end of 1933, the obvious having been exhausted, some advertisements were placed in the Philadelphia newspapers requesting the descendants of Oliver Evans to communicate with me. The results were disappointing, as only a scant dozen letters were received, and of these, none of the writers could offer any conclusive proof of descent, although all claimed this honor. By the commencement of 1934 Mrs. Bathe, who had already rendered considerable aid by helping me with some of the arduous letter writing, now volunteered to take full charge of this ever-increasing problem, and we both plunged deeper and deeper into unraveling Oliver Evans' life, by following up every lead and suggestion offered by all and sundry. And so for a period of four months an average of thirty long and questioning letters were dispatched each week to predetermined "victims" who in most cases entered most cheerfully into the spirit of our investigations. Many interesting discoveries of holographs were made in all sorts of odd corners of the country. One of the most valuable finds close at home was a dusty brown package containing a hundred or more letters and documents pertaining to Evans and his associates which recently came to light at the time the Franklin Institute removed from the old Seventh Street building to their magnificent new home on the Parkway.

In the summer of 1934, a visit to England was undertaken with the object of finding out if the steam-engine drawings and specifications which Evans sent to England on three separate occasions might still be in existence, but of these, there could unfortunately be found no trace, although much other important relative matter bearing on his associates was unearthed.

Upon our return an immediate visit to the University of Michigan was necessary and a full week was spent under the guidance of Professor Worley in the Transportation Library, examining the collection of writings and drawings, the gift of the late Alba B. Johnson in 1927, executed by Evans covering a period of some thirty years of his life.

In addition to the foregoing sources of information, and many others of a like nature, the files of the old newspapers from the year 1790 until 1826 were culled for items referring to Oliver Evans and his work. This was carried on simultaneously by independent research workers in Philadelphia, Pittsburgh, New York, Washington, Boston, Lexington, Ky., and even in Marietta, on the Ohio River. And from these prints some of the most interesting results were obtained.

EVANS NOT A DISCOURAGED AND DISAPPOINTED INVENTOR

From this brief survey of some of the work involved in gaining a firm grasp on the personality of Evans, it would perhaps be proper here to explode an all too readily accepted statement often made that Evans was but a discouraged and disappointed inventor who died finally in much poverty. Unlike John Fitch, whose dark and saturnine disposition was always his greatest enemy, hampering his genius and ofttimes alienating his best friends, Evans seemed able to rise superior to his difficulties and oppositions; and thus gradually with the passing years he was able to acquire much substantial property, as well as the interest and respect of many prominent men of his day.

Evans, whose ancestry blending as it did both the Celtic fire of the Welsh and the stolid qualities of the Dutch people, rendered him capable of pressing on to victory or standing firm in times of stress. Evans was by nature essentially the business man with the instinctive ability for inventing and adapting all things to furthering both his own and his country's needs and interests.

TWO OUTSTANDING CONTRIBUTIONS

Evans' two outstanding contributions to his countrymen were the many improvements he effected in the manufacture of flour by the use of new and ingenious machinery, and for this benefit alone he should have had some concrete recognition long ago, and, secondly, the introduction of the high-pressure steam engine into commercial manufacturing, which opened up more possibilities for prosperity in the United States than any other outstanding invention of that day.

In this last statement there is no intention to ignore the work of other contemporary engineers but rather to place Oliver Evans in the prominent position that he should occupy in those early formative years of American science and engineering.

Oliver Evans was born in the middle of the 18th century and lived to be sixty-four years old. He had to stand on his own feet from an early age and there is no evidence to show that he ever received any financial assistance from his family and but little from any one else. All of the assets he had accumulated by the time of his death were but the just dues of his life's efforts. And so to Evans' early struggle with poverty must be placed the late development of some of his inventions, notably the steam engine, which formed the first step toward steam railroads which Evans so ardently advocated most of his life but did not live to see accomplished.

IMPORTANT WORK STARTED AFTER MIDDLE LIFE

Evans was well past middle life—he was 51 years old to be exact, before he was really able to get under way—when in 1806 he built his manufactory on the Ridge Road and began to turn out there a vast array of engineering products. Evans had been established in Philadelphia as far back as 1792, and at various addresses he had carried on the business of a millwright and purveyor of millers' supplies. Thus for 27 years this city was his home and it was here that the most colorful and useful period of his life was spent.

It is my hope, and that of my co-author, that from our work[1] dealing with Oliver Evans and his times, which has been so generously sponsored by The Historical Society of Pennsylvania, a better knowledge and truer value of this outstanding man may be obtained in his own country and in his own city, for at present it is safe to say Evans is, and has been, better appreciated on the other side of the Atlantic than he has been here.

In the course of some conversation with Harrison W. Craver, Director of the Engineering Societies Library, about a year ago I remarked that there had never been any proper recognition of Oliver Evans in America. Dr. Craver very pointedly responded that "the reason was so little was really known about Evans," to which at that time I could but sadly agree. I think, however, that we owe it to ourselves as well as to the memory of Oliver Evans, to become better acquainted with this remarkable engineer and inventor, who, if I may speak paradoxically, has always been remembered, yet has so long been forgotten.

AERIAL PHOTOGRAPHY

A Discussion of the Technique of Getting Good Photographs From the Air

By B. B. TALLEY

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AERIAL photography, as the term implies, is photography from the air. The base or support for the camera may be a balloon, an airplane, a kite, or any other object supported within the air above the earth. By this limitation a picture taken from a peak or a precipice would not be an aerial photograph, but a terrestrial photograph.

Aerial photography is usually classified as "oblique" or "vertical." The basis for this classification is the angle at which the camera is held with respect to a plumb line from the aerial camera station to the earth.

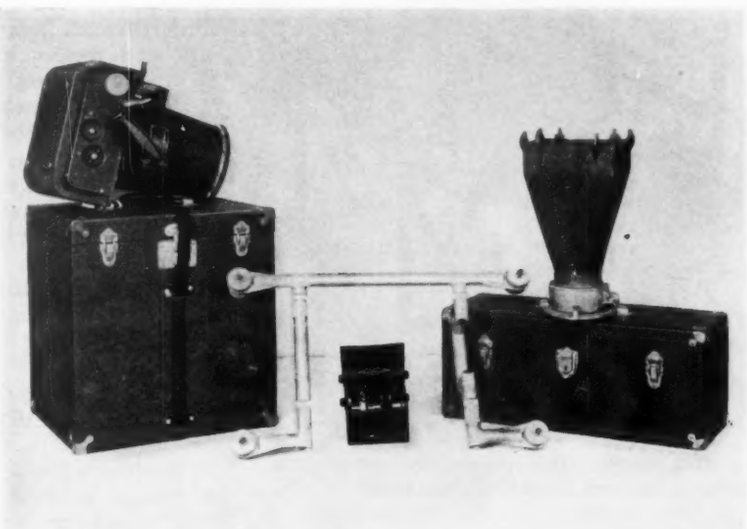

FIG. 1 K-10 AERIAL CAMERA WITH CARRYING CASES AND ACCESSORIES FOR MAKING VERTICAL AND OBLIQUE PHOTOGRAPHS

Oblique photography is usually limited to spotting or pin-pointing, although it may be used in mapping, and is most adaptable to the amateur. News photographs are usually obliques because they present the object photographed in an easily recognizable manner. An oblique photograph of an office building, a country estate, or a bridge has a better pictorial effect than a vertical photograph. Oblique photographs are ordinarily made with a single-lens camera, although in some cases multiple-lens cameras are used.

The Canadians have done excellent work in the utilization of oblique aerial photographs in mapping and have developed valuable methods and equipment for this use. Such photographs are adaptable to rapid mapping of tremendous areas and are used in woodlands and lake areas of northern Canada.

Vertical aerial photography may be subdivided into "spotting" and "mapping." Spotting, or pin-pointing, is the term usually applied to the making of a vertical photograph of an isolated point or small isolated area which may be covered by a single photograph. In military usage, particularly for artillery and ground troops, the photographing of important enemy works might be accomplished by pin-pointing, as an object would be photographed from a point directly above it and would show the location of enemy works in relationship to other objects in the vicinity.

COOPERATION BETWEEN PILOT AND PHOTOGRAPHER ESSENTIAL

Photography for mapping purposes is often quite involved. First, certain limitations are imposed if maximum use is to be made of the photographs. In order to accomplish the desired results with these limitations, the pilot and photographer, for long periods of time and at high altitudes, must maintain strict attention to their work and exercise their utmost concentration, often at a temperature of 20 to 30 F below zero, while using oxygen. The pilot must not only fly from one point to another but in a given direction at a constant altitude while holding his plane level, both laterally and longitudinally. As an additional handicap it is unusual for the pilot to find definite objects of reference by which to establish his line of flight. There may be a window in the bottom of the plane beneath the pilot's feet through which he can study the terrain immediately under him, but that does not always solve the problem. In a cross-wind he will have to yaw the plane, and objects directly below and along the line he is trying to follow in flight no longer appear in the window; hence he must observe from the side of the plane or over the engine, and pick up distant points with which to guide his flight. This type of flying is often referred to as being the most difficult for a pilot. By "difficult" is not meant "hazardous;" but such flying is difficult because of the mental concentration and physical alertness required to accomplish the desired result.

For the photographer the requirements imposed are no less rigid than for the pilot. First, the photographer must maintain the crab of the camera so that the ground objects move straight across its focal plane, regardless of the yaw of the airplane. Second, he must make exposures at proper intervals of time to obtain the correct overlap between successive photographs. In this it is necessary that he maintain constant vigilance, as the ground speed of the plane may vary considerably in a single strip and it is unusual for it to remain the same in successive strips. Third, the observer must hold the camera level at the instant of exposure. If he has an experienced pilot, this last is the easiest part of his task.

Although the observer is not charged with the responsibility of keeping the plane on its course, he should cooperate with the pilot in assisting him to maintain the correct line of flight without annoying with useless conversation. Likewise, he

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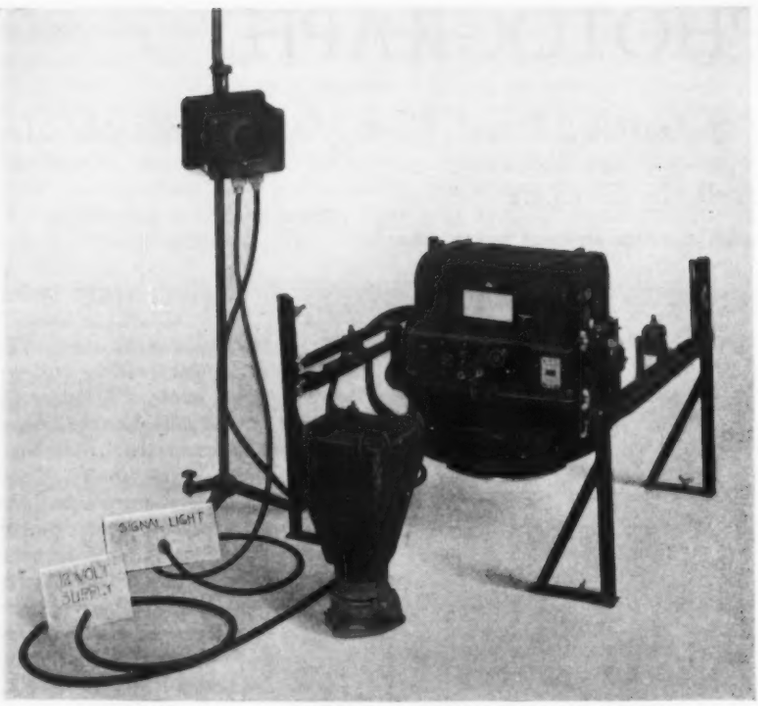


FIG. 2 K-3B AERIAL CAMERA WITH MOUNT, VIEW FINDER, INTERVALOMETER, AND CABLE CONNECTIONS FOR FULL AUTOMATIC OPERATION

should restrict his movements about the plane, as each movement forward or backward unbalances the plane and causes it to climb or descend. At very high altitudes movements as slight as the observer's leaning forward to level the camera are detected by the pilot who must change his controls to compensate for them.

A multiple-lens camera covers a wider area than a single-lens camera when the plane is flying at a given altitude and hence less flying is required. Except for the amount of flying necessary, the duties of the pilot and observer remain the same.

WHAT KIND OF A CAMERA SHOULD BE USED

It is not necessary that a person interested in aerial photography as a hobby be burdened with acquiring any considerable amount of expensive equipment. The question may arise: Are ordinary cameras satisfactory for aerial work? The answer to this, of course, is: It depends upon the camera. Likewise, it depends upon the type of airplane with which the camera will be used. In a commercial transport or cabin plane there is no reason why oblique photographs obtained with ground cameras should not be satisfactory provided the conditions of exposure and development are fulfilled. The greatest objection to pictures obtained by ordinary or ground cameras is the size of the images. The ordinary camera is designed to photograph objects relatively close to the photographer. It cannot, therefore, be expected that objects at a considerable distance will appear as large as they would if they were close at hand.

From an open plane, where it is necessary in order to take the pictures, to hold the camera in the slipstream of the propeller, the camera must be sufficiently rugged to withstand the resulting blast of air. One could not expect a camera with a large viewing hood or flexible bellows to withstand this force, and the use of such cameras in this manner is not recommended. There are, however, certain small cameras which will give good results, although the images obtained with them may be smaller than desired. For example, there is one which takes a picture 2 by $2^1/_2$ in. with a lens which will permit enlargement to 4 or 5 diameters (or larger) without undue loss of detail. It holds enough film for 50 exposures. It may be fitted with a variety of interchangeable cones giving a range of lens speeds from F/2.3 to F/6, focal lengths from 2.5 to 10 in., and shutter speeds from $^1/_{30}$ to $^1/_{1000}$ sec. It contains an adjustment for additional speeds from one to $^1/_{30}$ sec.

If one is more ambitious, a type K-10 camera, shown in Fig. 1 may be obtained. It takes 5 by 7 in. photographs which do not require enlargement. It is suitable for professional as well as amateur work. For one who is interested in the investigation of tracts of land, in photographing properties, in aerial geological reconnaissance, or in news photography, such a camera is entirely suitable. The K-10 camera holds sufficient film for either 24 or 36 exposures. The 24-exposure roll is made for daylight loading and the 36-exposure roll may be loaded only in a dark room.

For strictly professional use, the U. S. Army Air Corps type K-3B camera, shown in Fig. 2, is one of the best that can be obtained. It may be fitted with a wide variety of lenses and cones, with focal lengths varying from $8^1/_4$ to 24 in. All the cones are interchangeable. The magazines are self-contained units and hold enough film for 110 exposures. The magazines can be changed in the air in a few seconds and the use of additional magazines makes it possible to take an indefinite number of photographs in a single flight. It should never be necessary to land in order to obtain supplies of additional film.

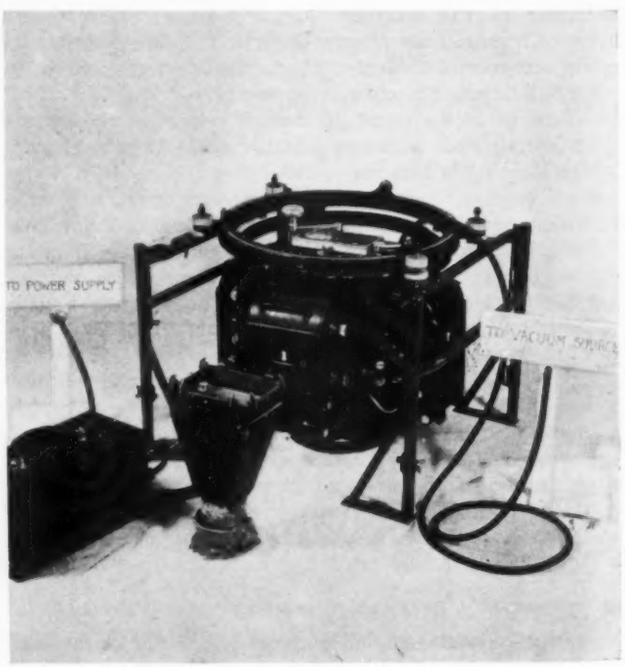


FIG. 3 T-3A (FIVE LENS) AERIAL CAMERA WITH SEPARATE VIEW FINDER AND ELECTRIC SURGE BOX

The type K-3B aerial camera is an all-purpose camera. It may be used for taking obliques over the side of an open ship, or through the door of a cabin plane, or for vertical through the bottom of the fuselage with cones varying from $8\frac{1}{4}$ to 24 in., depending upon what is desired.

Built as an integral part of the K-3B camera is a stopwatch, a level bubble, and a counter for indicating the number of exposures. Attached to the camera is an electric motor and cable attachment for full automatic operation. By using the electric motor and intervalometer the camera is fully automatic and will take photographs at any desired interval of time. The mechanism trips the shutter, rewinds the film, and at the end of the selected interval repeats the cycle until all of the film is exposed.

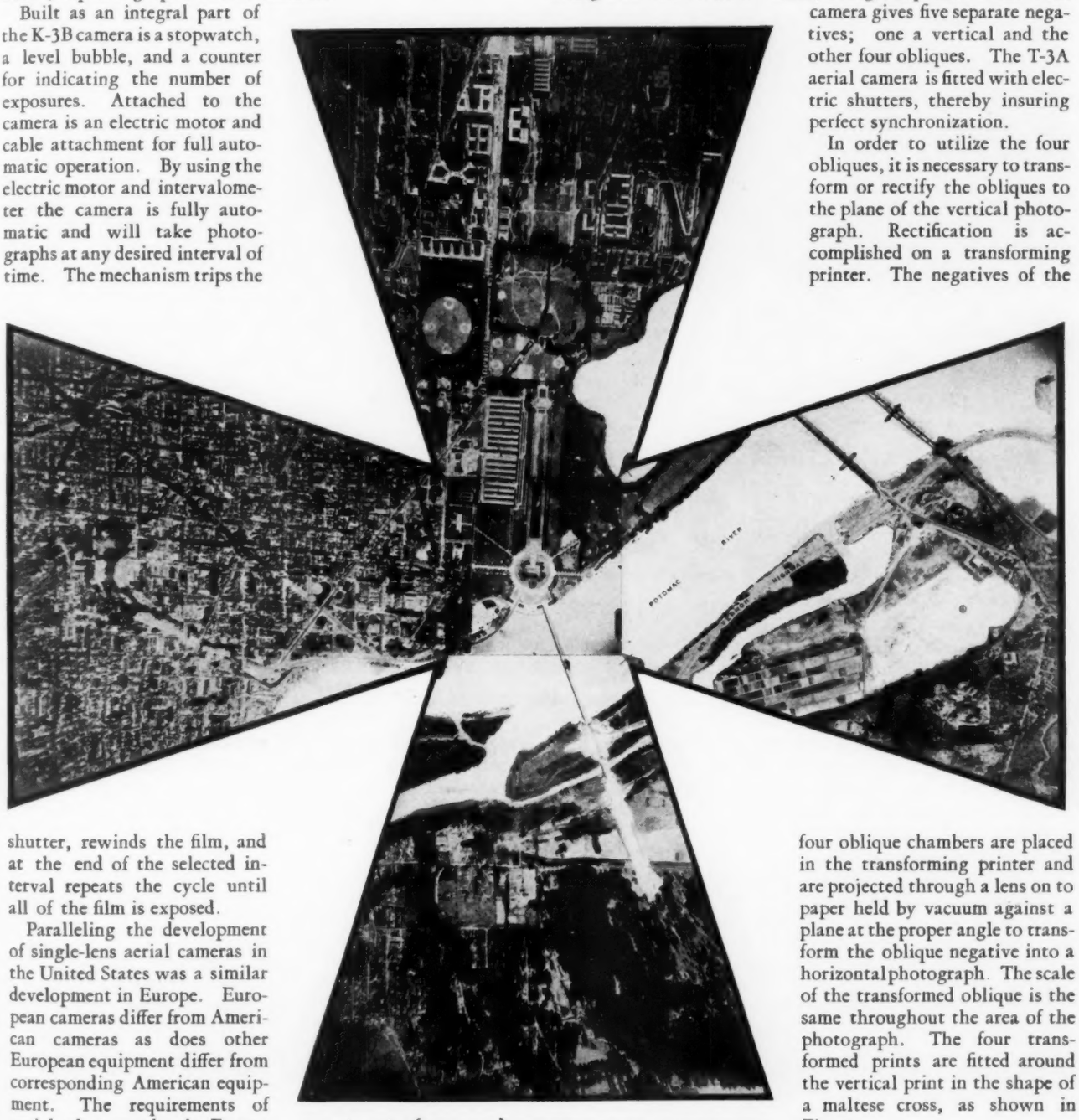


FIG. 4 T-3A (FIVE LENS) COMPOSITE AERIAL PHOTOGRAPH TAKEN OVER WASHINGTON, D. C.

Paralleling the development of single-lens aerial cameras in the United States was a similar development in Europe. European cameras differ from American cameras as does other European equipment differ from corresponding American equipment. The requirements of aerial photography in Europe are not those found in the United States and each continent has developed cameras peculiar to its own requirements.

For multiple-lens aerial photography there is a marked dissimilarity between European and American cameras. In America the present standard multiple-lens camera is the type-T-3A five-lens camera, shown in Fig. 3. It is strictly a mapping camera. The five-lens camera is essentially five cameras built into a single frame. Each camera is fitted with its own lens, shutter mechanism, film magazine, and cone; and all are tied together with a single operating mechanism. The lenses of the T-3A camera are so arranged that one lens takes vertical pictures and the other four oblique pictures at an angle of 43 deg with the vertical. Thus, a single exposure of the T-3A camera gives five separate negatives; one a vertical and the other four obliques. The T-3A aerial camera is fitted with electric shutters, thereby insuring perfect synchronization.

In order to utilize the four obliques, it is necessary to transform or rectify the obliques to the plane of the vertical photograph. Rectification is accomplished on a transforming printer. The negatives of the four oblique chambers are placed in the transforming printer and are projected through a lens on to paper held by vacuum against a plane at the proper angle to transform the oblique negative into a horizontal photograph. The scale of the transformed oblique is the same throughout the area of the photograph. The four transformed prints are fitted around the vertical print in the shape of a maltese cross, as shown in Fig. 4.

Two T-3A cameras may be operated in tandem to give a nine-lens composite as shown in Fig. 4A. This photograph was made at an altitude 28,200 ft and covers 675 sq mi.

From casual observation it might appear that this unusual shape of the T-3A shown in Fig. 4 composite photograph is a handicap to its ultimate utilization, but such is not the case. The advantage of the five-lens camera lies in the great width of the area it covers. For every 1000 feet of altitude at the in-

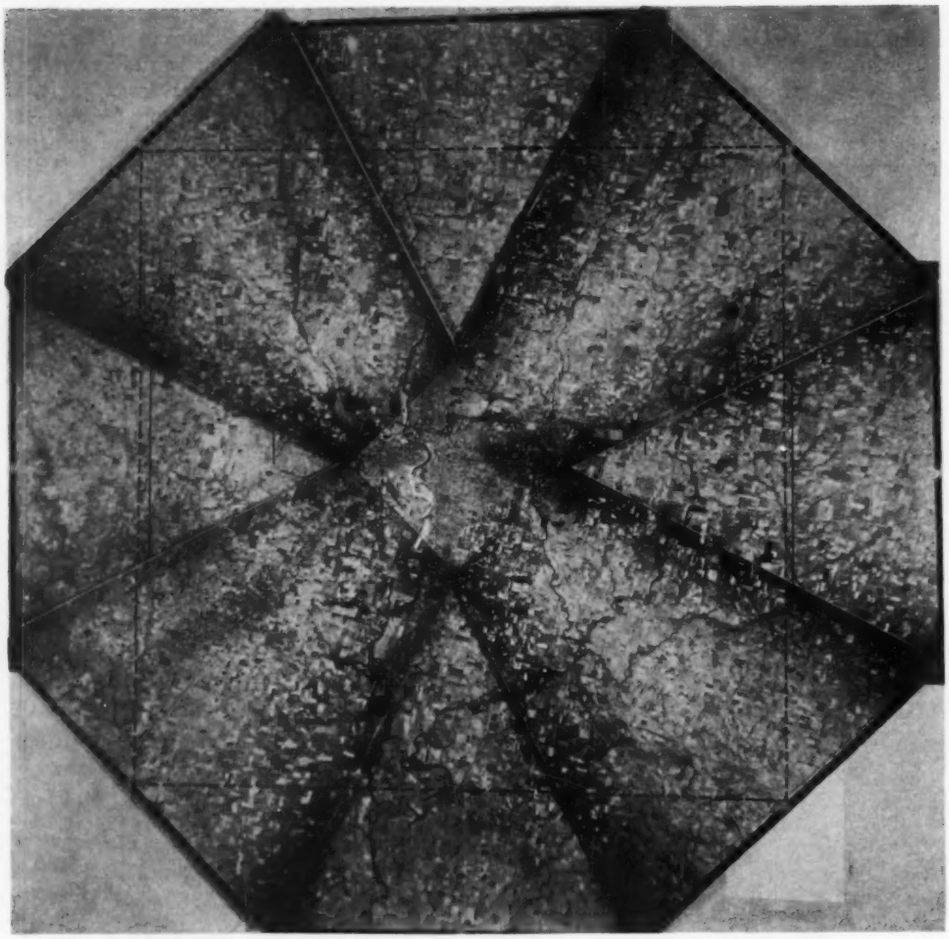


FIG. 4A T-3A NINE-LENS COMPOSITE TAKEN OVER COLUMBUS, OHIO, FROM 28,200 FT

stant of exposure the width of territory covered by the five-lens photograph is approximately one mile. For example, at 1000 ft the width covered is one mile, at 10,000 ft ten miles, and at 20,000 ft 20 miles. The pictures are ordinarily taken with a 60 per cent overlap of the B or vertical prints. Thus, all image points fall on at least three successive photographs. This is necessary for mapping by the radial-line method and for stereoscopic plotting. In covering large areas there is ordinarily 30 per cent sidelap between adjacent strips. In tandem operation the overlap is no longer 60 per cent of the B-print but is 60 per cent of the whole, thereby considerably reducing the number of photographs required to cover a given area. The T-3A camera is used by the U. S. Army Air Corps, Corps of Engineers, the U. S. Coast and Geodetic Survey, the Geological Survey, and many other mapping agencies, both governmental and civilian.

The Fairchild Aerial Camera Corporation is at present constructing a nine-lens camera for the U. S. Coast and Geodetic Survey (not to be confused with the tandem operation of two T-3A, 5-lens, cameras). This camera will make an octagonal photograph whose diagonal is approximately 31 in. The photographs of this camera will, generally speaking, fill in the gaps in the quadrants of the maltese cross of the five-lens camera. However, the cameras are dissimilar in construction and in the manner of obtaining the final photograph. The nine-lens camera takes one vertical and eight obliques that will be transformed into verticals. The weight of one five-lens camera is about 75 lb, and that of the nine-lens camera about 300 lb.

In addition to the American multiple-lens cameras, the German Zeiss four-couple camera is used in this country to some extent. The Zeiss four-couple camera, shown in Fig. 5, is adapted for use with the Zeiss stereoplanigraph, owned and operated by a commercial mapping organization in the United States.

Unfortunately, there has not been sufficient interest in the United States in stereoscopic mapping to stimulate domestic development of stereoscopic mapping instruments. However, in recent years some foreign stereoscopic mapping instruments have been adapted to American mapping cameras. Among these are the multiplex aero-projector, shown in Fig. 6 and the aerocartograph, shown in Fig. 7. The multiplex aero-projector is adaptable to negatives from K-3B and T-3A cameras, and the aerocartograph to the T-3A camera. In each case both verticals and obliques of the T-3A cameras are used.

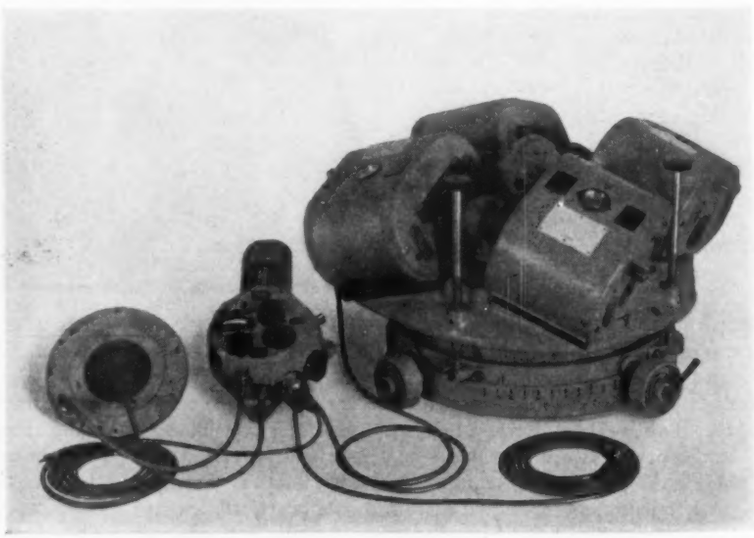


FIG. 5 ZEISS FOUR-COUPLE AERIAL CAMERA WITH ACCESSORIES

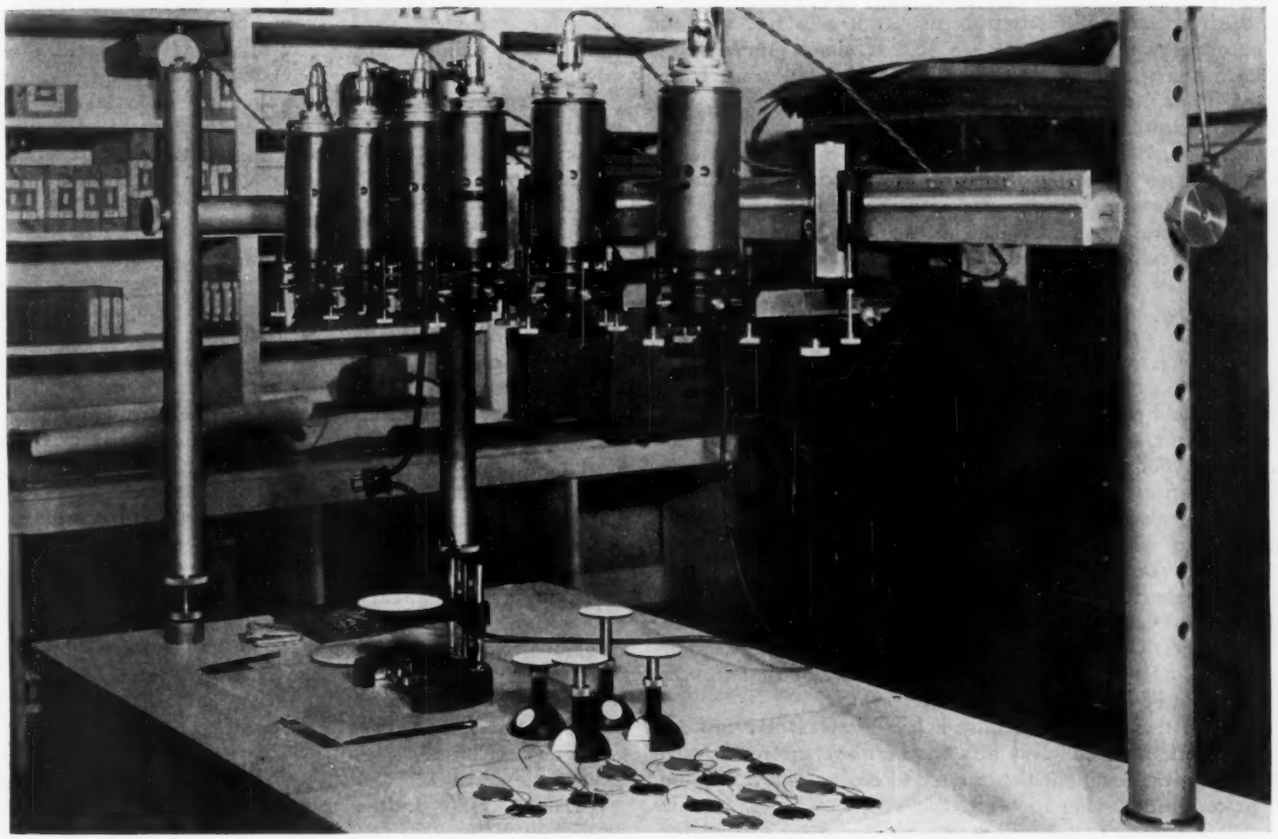


FIG. 6 ZEISS AEROTOPOGRAPH MULTIPLEX AERO-PROJECTOR

FILMS, EXPOSURE TIME, LENS SPEED, SHUTTER SPEED, FILTERS, DEVELOPMENT TIME

Supersensitive panchromatic film will probably give the most satisfactory results in aerial photography. It was developed primarily for aerial use, and while there are other excellent films on the market, supersensitive panchromatic is available and the results obtained from it have been consistently good. Glass plates may be used with some aerial cameras.

Often for the amateur and sometimes for the professional man the results obtained from aerial photographs are disappointing. Such disappointments may be attributed to many causes. In discussing ways to eliminate these disappointments, let us assume that the camera used has the proper range of exposures and a proper lens. It should, of course, be sufficiently strong and rugged for aerial use. If the camera has these qualities, satisfactory photographs should not be difficult to obtain.

Aerial photographs are made from a moving airplane. The effect is the same as though pictures were made of an object moving at the same rate of speed and it is necessary, therefore, to use the shortest possible exposure. Good aerial photographs are occasionally made with an exposure as great as $^1/_{20}$ sec, but this is rare, and the motion of the camera usually destroys the sharpness of image. One-fiftieth of a second is about the longest exposure which should be considered, and it only under certain conditions.

Tied closely to exposure time is the direction the camera is pointing with respect to the object being photographed. If the camera is pointed directly ahead or over the tail of the plane, a longer exposure can be used than if it is pointed perpendicular to the line of motion of the plane. The ideal location from which to take oblique photographs is the nose of the airplane flying directly at the object; but when this condition cannot be obtained, a direction 45 deg back from the wings of the plane and downward at an angle that will cause the horizon to appear about midway in the upper half of the photograph is second best.

For vertical photographs the camera is pointed directly downward, i.e., perpendicular to the line of motion of the plane, and an exposure corresponding to this line of motion must be allowed. Likewise, on photographic missions, the pilot should assist the photographer by reducing the airplane speed, or, in obliques or pin-pointing, by putting the plane into a glide with the throttle partially closed. Particularly is this advantageous if the photographer must stand up in the cockpit and hold the camera over the side of the plane.

Second in importance is the lens speed, which was not considered in the discussion of exposure time because the effect of the motion of the plane must first be eliminated. As a partial guide in this matter, with the K-10, the K-3B, and the T-3A cameras, it is customary to use a diaphragm setting somewhere between F/4.5 and F/8.0. In using an F/4.5 wide-angle lens it is not unusual to get a negative of uneven density. This, of course, is due to low shutter efficiency, but it makes it desirable to use the smallest possible diaphragm. However, a film of uneven density does not necessarily mean that the print will have unequal density, as this can usually be corrected during printing.

Rarely will lenses be stopped down to a greater extent than to F/8.0. The most suitable aperture for the lens will depend upon the circumstances. Lens speeds, of course, cannot be covered with a few general remarks.

With reference to shutter speeds, let it be stated that for photography taken at less than 3000 ft above ground level, the shutter speeds should not be lower than $^1/_{100}$ sec. However, if one is particularly skillful he may sometimes get good results at low altitudes with $^1/_{50}$ sec by closing his lens a corresponding amount, but long exposures at low altitude are certainly not to be recommended as a general rule. How much faster speeds than $^1/_{100}$ sec are necessary will depend upon the circumstances, but for low altitude work $^1/_{150}$ sec or $^1/_{200}$ sec is better, providing of course that the lens can compensate for this increase.

As one approaches altitudes of 5000 or 10,000 ft, the exposure intervals may remain at $^1/_{100}$ sec (or, rather, the exposure time may be increased to $^1/_{100}$ sec), depending upon the light conditions, i.e., the time of day, the condition of the sky, the latitude, and the time of year.

Light intensity along the same parallel of latitude is not uniform. For example, in Ohio, one would not use the same camera setting as in Kansas. Therefore, if one intends to do extensive aerial photography, he should make a test in the locality in which he contemplates work. In doing this, he should take pictures at the desired altitude with a wide range of shutter speeds and diaphragm openings. The film should be developed and studied, and a decision made from the actual condition of the film as to what camera settings should be used. At the same time the proper development for the film should be determined.

The amateur who takes only a few pictures may make a determination which gives him the best average results and then vary it throughout the country according to altitude and light conditions. For high altitude, i.e., 15,000, 20,000, and 25,000 ft, shutter speeds will decrease to about $^1/_{60}$ sec and the diaphragm opening will increase to about F/6.8 to F/5.6, and perhaps even to F/4.5, if the lens can cover the plate at this wide opening.

In professional aerial photography, it is customary to use a "minus blue" filter to penetrate ground haze at altitudes above 5000 ft. An A-2 filter is used for altitudes below 5000 ft. There are many filters, but in case of doubt one will not go very far wrong by using a minus blue filter. However, a study of actual conditions should be made before selecting a filter that will give the best results, and one should take advantage of his own experience under similar conditions.

The chemicals used in the development of aerial film are about the same as those used in the development of ground pictures, with a leaning toward those giving a finer grain. The finer grain is desired because of the smallness of images in aerial film.

A good aerial picture usually possesses a greater degree of contrast than is ordinarily found in a ground picture. Therefore, it is developed differently and it is the development of aerial film that gives rise to much of the disappointment of amateur aerial photography. Aerial film must be developed longer than ground film.

A good rule of thumb is to assume that aerial film will be developed one minute for every 1000 ft of altitude, with a minimum development time of 10 min, and a maximum of 20 min. However, while for 5000 ft the time is 10 min for 1000 or 2000 ft it might be decreased to 6 or 7 min. This rule should be considered as a guide and be varied according to circumstances and experience.

To make an absolute determination of the correct time of development, one should make several exposures in the area for which a test is desired. The film is cut into short lengths of one or two exposures and these short pieces are subjected to different development times. With such a procedure it is easy to detect the point at which the film varies from underdevelopment to overdevelopment, and hence the correct time to use in developing the film. Such tests are habitually used in professional work.

It is not necessary for the amateur to run such tests each time he takes a picture. If he develops his own film he will soon learn the correct development time. If, however, he does not develop his own film, but makes the pictures for the test, explains this to the person who develops the film, and requests such a test, it can be made for him and used thereafter, the time being varied as light conditions, exposure, and altitude change. Only an inch or two of film is required for such a test.

From what has been stated it may appear that good aerial photography is impossible of accomplishment. This, however, is not the case. There is no reason to believe that the results from aerial photography for a beginner should be any worse than his first results in ground photography. It is no more difficult to learn to take good pictures from the air than it is to learn to take good pictures from the ground. It is merely that different conditions must be taken into account.

It is not necessary for one to know all of the color sensitivities of his film, or to be equipped with a large range of filters and with other expensive apparatus in order to get good pictures from the air. The science has advanced to a point where one may obtain film and equipment from a reputable manufacturer, by merely stating for what purpose he intends to use it.

FIG. 7 AEROCARTOGRAPH

MILITARY AIRCRAFT ENGINES *of the* FUTURE

By FORD L. PRESCOTT

U. S. AIR CORPS, MATERIEL DIVISION, WRIGHT FIELD, DAYTON, OHIO

AT THE present time the four-stroke Otto-cycle gasoline engine of 9 to 14 cylinders, either air or liquid cooled, stands practically alone in the field of military-aircraft engines. It has been charged that engine designers have closed their eyes to other types of engines and operating cycles and given undue attention to the development of the four-stroke engine. But it may be well to remember that a steam automobile could be purchased in 1905 for $650, and that it would "out-perform" any gasoline automobile on the market at that time. In open competition the gasoline car outstripped the "steamer" and finally drove it off the market, in spite of many truly worthy efforts to revive steam power. The excellent operating qualities and mechanical simplicity of steam power could not offset the fire hazard incidental to pilot burners, the delay caused by cold boilers, and the high degree of mechanical ability called for to operate the steam power plant successfully. The advent of "self-starters" on gasoline cars reduced the problem of quick power to stepping on a push button.

There have been serious attempts to adapt steam power to aircraft, but to date the power-plant and fuel weights have been excessive, and the condenser requirements almost prohibitive. Efforts have also been expended on jet propulsion, which admittedly offers the only known means of propelling a ship through outer space. However, it appears to offer a low order of propulsive efficiency within the earth's atmosphere, and the "take-off" of a rocket ship would be accompanied by a tremendous belching forth of burning gases, likely to set fire to objects within a hundred feet of the tail. Space flying would be extremely hazardous, because of the large number of meteors of varying sizes, all apparently moving with velocities of the order of 40 miles per sec. A bit of meteoric ore the size of a pea, moving at a velocity nearly 80 times the muzzle velocity of a Springfield-rifle bullet would be a formidable missile. Use of fuels carrying their own oxygen supply is of course prohibitive from the weight standpoint.

PREEMINENCE OF INTERNAL-COMBUSTION ENGINE

By process of elimination, therefore, the internal-combustion engine appears at the present time to have a clear field. There are, of course, two main types, Otto and Diesel cycles, or spark- and compression-ignition engines. Of each type there are two- and four-stroke designs, each with its peculiar advantages and disadvantages. The two-stroke Otto-cycle carburetor engine was early found to be subject to spells of moroseness and would sullenly refuse to start, particularly at inopportune moments. The author has fought such an engine for hours, only to find, after leaving in disgust and returning later, that the contrary little cuss started at the first turn of the flywheel and ran sweetly for no good reason at all. The story might have been different with fuel injection in place of carburetion, and the recent development of satisfactory fuel injectors may reopen the two-stroke Orto-cycle field for development. The four-stroke engine is reliable and capable of high output per cubic inch of displacement and per pound of weight. Its brake thermal efficiency is about 29 per cent, and tests are on record at the Matériel Division, where a fuel consumption of 0.39 lb per bhp-hr was attained, giving a brake thermal efficiency of 33.5 per cent based on the lower heating value of gasoline. Further increase in efficiency might be obtained with increase of expansion ratio, but this unfortunately also means increasing the compression ratio, so that the auto-ignition properties of gasoline become the limiting factor. Recent developments in the field of gasolines of high octane number are, of course, pushing this frontier beyond present-day developments.

It is, of course, inherent in the Otto cycle to burn the fuel explosively or at constant volume. This, with the low compression pressures attained in practice, gives the largest practicable ratio of mean effective to maximum pressure and results in a favorable weight-power ratio. The compression-ignition cycle may, of course, be operated with substantially constant-volume combustion, but the peak pressures become extremely high and the simulation of detonation becomes realistic. The ratio of mean effective to maximum pressure is not favorable and the result is a high weight-power ratio. At slow speeds the card can show nearly constant-pressure combustion; but at the speeds required of aeronautic engines, the constant-volume condition must be approached because of the extremely short combustion period. Supercharging the Diesel engine will require a lowering of the expansion ratio and preheating of the air, thus reducing the thermal and volumetric efficiency of the cycle. The author believes that with present knowledge the Otto-cycle engine can always develop more power per cubic inch and per pound of weight than can the Diesel, and with cleaner combustion when the fuel-air ratio is kept high as demanded by high specific output.

PRESENT-DAY TYPES OF AIRCRAFT ENGINES

The practicable arrangements of cylinders in military aircraft engines fall into two groups, radial and in-line. Each of these divides at present into a few simple classes as shown in Table 1.

TABLE 1 CLASSES OF RADIAL AND IN-LINE ENGINES

Radial	In-line
5-cylinder single-row	12-cylinder V
7-cylinder single-row	12-cylinder opposed
9-cylinder single-row	16-cylinder X
12-cylinder hexagonal	18-cylinder W
14-cylinder double-row	24-cylinder X

The 20- and 28-cylinder types are also in some respects attractive, with 5 or 7 radial banks of four cylinders in line with liquid cooling. The 5- and 7-cylinder radials are useful only in smaller sizes, while the 9- and 14-cylinder engines appear capable of development to 1000 hp or more, with air cooling. The in-line types appear at best advantage when

Contributed by the St. Louis Section and Aeronautic Division and presented at National Aeronautic Meeting, St. Louis, Mo., Oct. 10–12, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

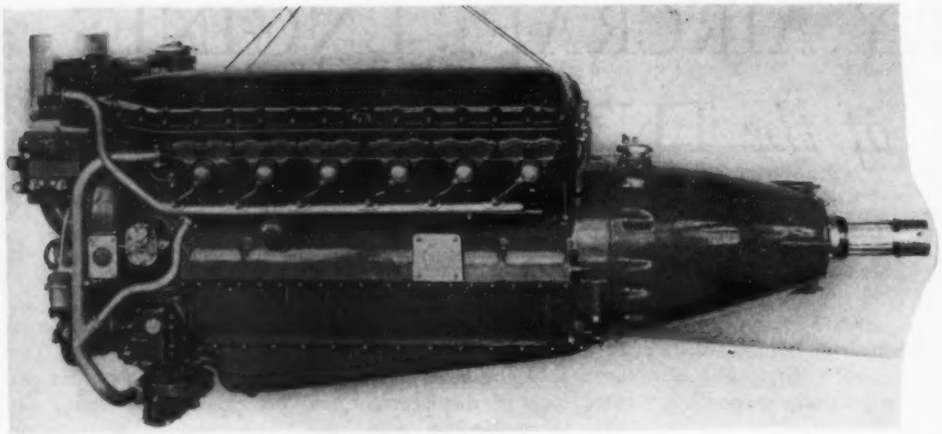


FIG. 1 LARGE IN-LINE "V" ENGINE

liquid-cooled. The 12-cylinder V and opposed types at present seem to offer the most in the 1000 to 1200-hp class.

It is often said that the limit of horsepower has been reached for air cooling or that it will be impracticable to handle more power in a single engine. However, there is no indication that the end has been reached in either of these matters. Large military engines, if successfully air-cooled, offer advantages in freedom from plumbing troubles and reduced vulnerability, which should not be overlooked. Blower cooling would reduce the power available to the propeller. This may be a good fault, since the derivation of cooling-air flow from forward speed is doubtless less efficient than the use of a well-designed blower, and the weight-power ratio of propellers goes up rapidly as power is increased.

The latter point shows little promise of improvement, since consideration of propeller-tip speed necessitates large propellers and reduction gearing. In 1918 a 420-hp metal propeller weighed 120 lb, or 0.286 lb per hp. In 1935 a 1000-hp metal propeller (controllable) weighs 450 lb, or 0.45 lb per hp. Incidental to the large propeller of today is a reduction gear adding 60 to 100 lb to the power-plant weight. On the other hand the dry weight of the 1918 engine was 845 lb, or 2.01 lb per hp, while that of the 1000-hp engine of today will not exceed 1200 lb, or 1.2 lb per hp, including the 60 to 100 lb of reduction gearing mentioned previously.

The built-in geared blower appears to be indispensable for supercharging. Without multispeed drives, however, this form of supercharger does not satisfy the demands of altitude performance, especially above 15,000 ft. For altitudes up to 35,000 ft or higher, the exhaust turbocompressor offers the most efficient means of maintaining sea-level performance, with the geared supercharger supplying the ground boost. There is also something to be said for a separate engine-driven blower for maintaining altitude performance. The problem of synchronizing several engines would be reduced by operating them from a single source of air maintained at sea-level pressure. Incidentally, the problem of accessory drives and mounting could be simplified by centralizing the accessories not vital to the operation of each engine unit. The present tendency in power-plant design is toward a high number of revolutions and high brake mean effective pressure, since both factors tend toward high output per cubic inch or per pound.

A fruitful field for inventive effort has been the unconventional engine. In spite of the fact that the most efficient mechanism for changing from reciprocating to rotating motion is still the crank, connecting rod, and crosshead, this mechanism has been a favorite point of attack. The author has come to the belief that a device which has withstood all the attacks of inventive genius for a century, more or less, has something to recommend it.

UNCONVENTIONAL ENGINES

In the field of the unconventional might be mentioned the gas turbine, upon which a large amount of effort has been expended. Marks and Danilov[1] have shown that expectations of high thermal efficiency from the internal-combustion turbine are not justified. Material limitations prevent utilization of a large value of T_1, and the noncondensable nature of the working medium prevents reduction of the value of T_2. However, as in jet propulsion, the efficiency should increase with altitude.

"Barrel" type engines, as exemplified by the Almen, Michell,

[1] "Gas Turbines," by L. S. Marks and M. Danilov, Trans. A.S.M.E., vol. 46, 1924, pp. 1095–1129.

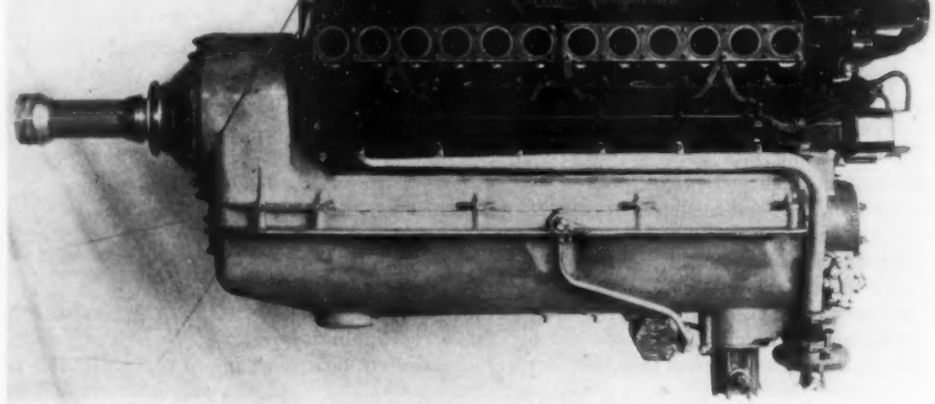


FIG. 2 12-CYLINDER NONSUPERCHARGED "V" ENGINE

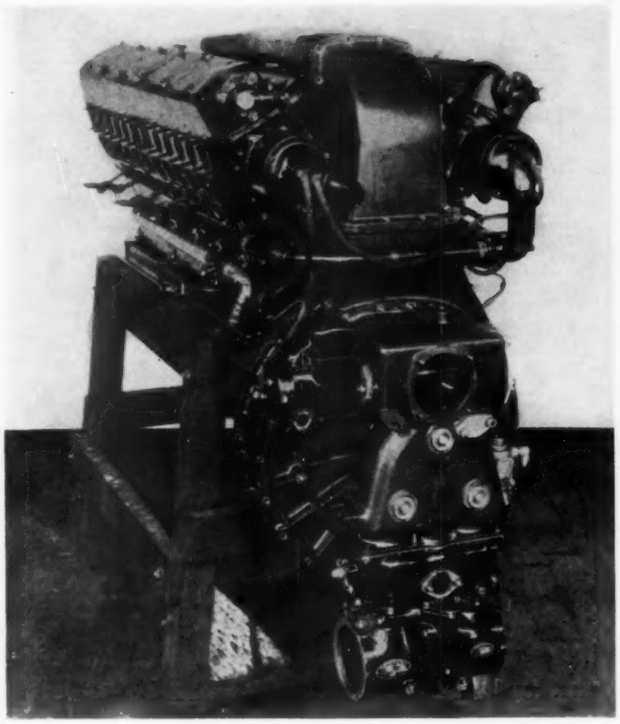


FIG. 3 12-CYLINDER "V" ENGINE, SUPERCHARGED

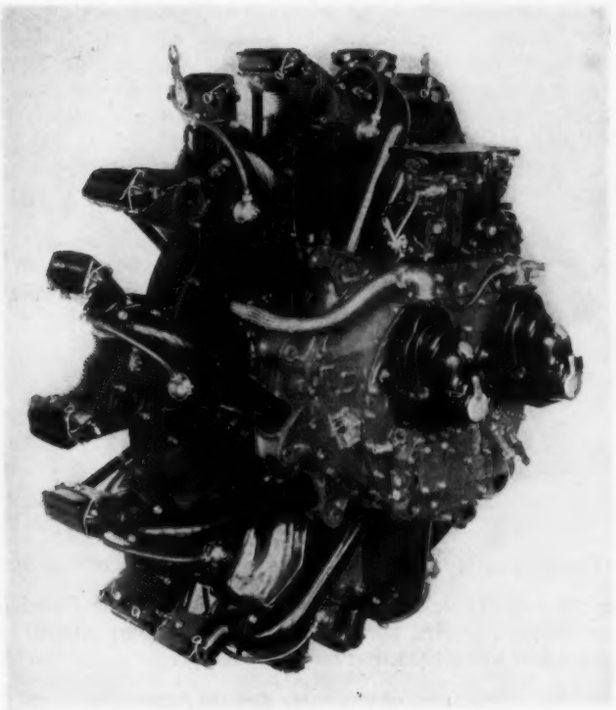


FIG. 4 SINGLE-ROW RADIAL AIR-COOLED ENGINE OF HIGH OUTPUT

and others, have always incited inventive effort. These have embodied the swash-plate idea in various forms, the Z-crank and cam types being similar in principle, and none of them shows the mechanical efficiency of the conventional engine mechanism.

New, or at present unexploited, sources of electrical or chemical energy will probably eventually solve the problem of diminishing petroleum resources, but such speculations are beyond the scope of this paper and the capabilities of its author. The following remarks are, therefore, based on observation at close range of present developments for use in the near future.

ENGINE OF THE IMMEDIATE FUTURE

The military aircraft engine of the immediate future will have a rating of 1000 to 1200 hp, with an emergency rating some 10 per cent greater. The dry weight will be 1.2 lb per bhp or less, including reduction gearing. The brake mean effective pressure will be 185 to 200 lb per sq in., obtained with a geared built-in centrifugal compressor. Ignition will be by means of high-tension magnetos. The number of cylinders will be 12 for the V or opposed types, with liquid cooling, and 9 or 14 for the radial air-cooled types. Crankshaft rotational speed will be 2500 to 3100 rpm. The fuel consumption at rated power will not exceed 0.5 lb per bhp-hr in the liquid-cooled types, and at cruising will be 0.45 lb per bhp-hr, or less. Fuel injection will probably be used, so that mixture distribution will be uniform. The direction of rotation will be optional, so that the torque in a two-engine installation will be balanced. For single-engine installations, dual propellers rotating in opposite directions will be required because of torque considerations. A single propeller utilizing 1200 hp at 1200 rpm produces a torque of 5000 lb-ft. To resist this torque by wing rigging entails sacrifice in the matter of drag. Propellers will, of course, be fully controllable in the interest of take-off load, speed, and fuel economy. Sea-level performance will be maintained at altitude by means of the exhaust turbocompressor.

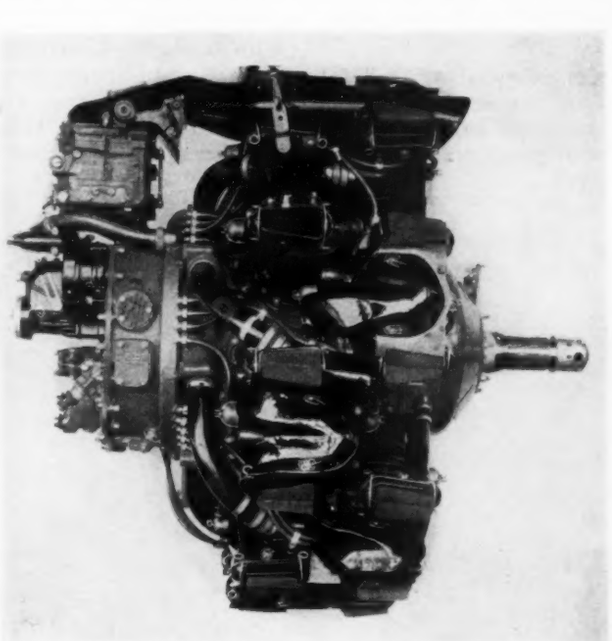


FIG. 5 TWO-ROW 14-CYLINDER AIR-COOLED ENGINE

Developments in the Diesel field may alter these specifications, but at present is a matter of speculation. The tell-tale plume of smoke from the Diesel-type engine will have to go before serious competition with the Otto-cycle type can occur

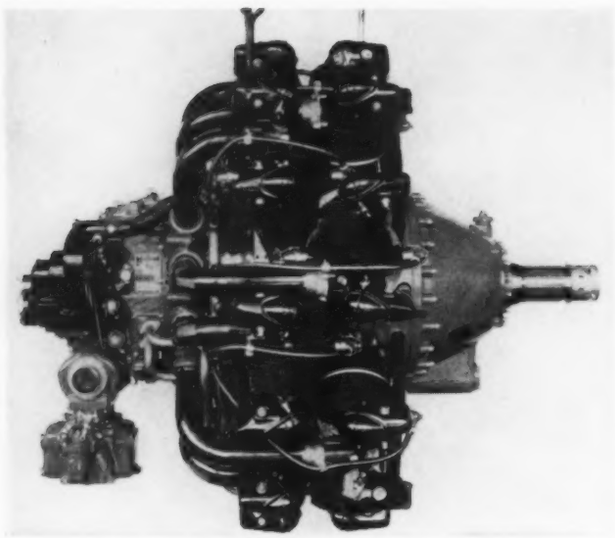


FIG. 6 LARGE TWO-ROW 14-CYLINDER AIR-COOLED ENGINE

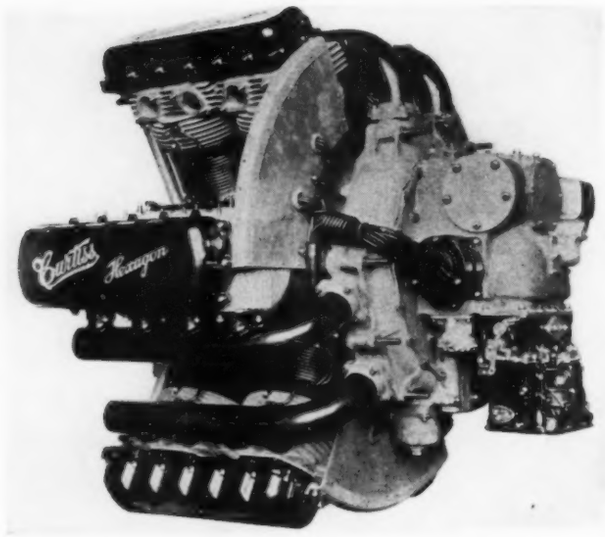


FIG. 7 12-CYLINDER AIR-COOLED HEXAGON ENGINE

in the military field. The weight handicap of the Diesel is not serious provided the fuel consumption can be kept 10 to 20 per cent lower than that of the Otto type.

ENGINES OF THE MORE REMOTE FUTURE

Treading lightly into the more remote future, indications are that 1500 to 2000 hp per engine will be demanded Weight per horsepower will be still lower than in the 1000–1200-hp field, running possibly from 1 lb down to 0.8 lb per bhp. Liquid cooling will be used, with low-drag or blower-cooled radiators, or, in the case of air-cooling, by means of blowers and pressure-type cowling. Cylinders will not exceed 6 in. in bore, and 18 to 24 or more cylinders will be required. High output per cubic inch and some form of compounding may result in lowering of the fuel consumption. Improved fuels may also permit raising the compression ratio without destructive detonation. Dual propellers with opposite rotation will be more essential than in the case of the 1000–1200-hp class.

The question of larger propellers, or more small ones will call for settlement, and the whole topic of propulsion may require new analysis, because of the airplane speeds which will be the rule. Predictions along this line must come from better qualified persons, more closely related to the subject of propulsion.

A few frontier marks that have been established may be of interest. The indicator cards of Fig. 9 appear to show that it will be possible greatly to increase the output per cubic inch by high supercharging pressures, provided improvement in fuels and spark-plugs is sufficiently advanced. Card *f* was taken under unstable conditions and represents several efforts to hold the output steady while securing the card. It is believed that this card represents a record for cylinder performance and also for indicator performance. A brake mean effective pressure of 579 lb per sq in. (actual) was recorded. Card *e* was taken at 539 lb per sq in. and the operation of the engine was steady. Card *d* shows an excellent weak-spring card at 494 lb per sq in. brake mean effective pressure, while card *c* shows the effect of knock suppression by water injection. Energy is absorbed during the period of rapid pressure rise, but definitely appears to be available during the working stroke. It seems probable that dissociation and recombustion take place in the cycle, with increase in thermal efficiency, since no changes were made in engine adjustments other than to admit the water. The shift in boost pressure of one inch of mercury accounts for $5^1/_2$ to 6 lb per sq in. brake mean effective pressure, leaving 9 lb per sq in. to be accounted for by increased combustion

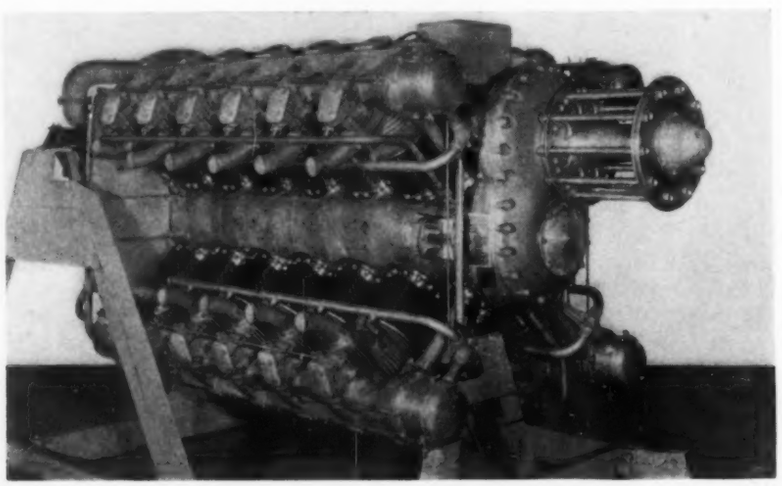
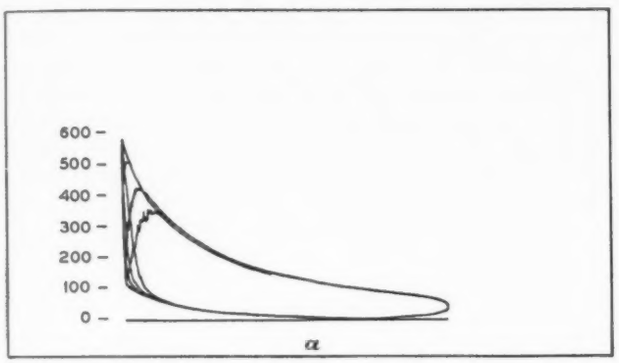


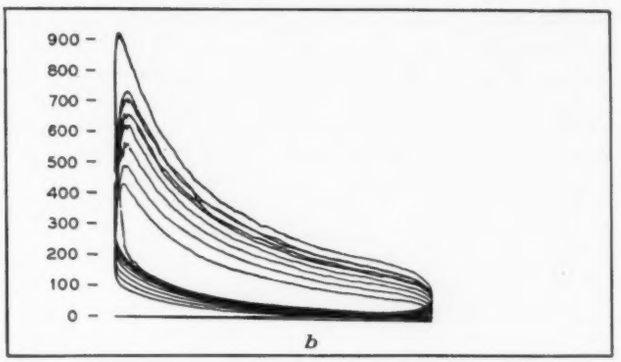
FIG. 8 24-CYLINDER "X" ENGINE

efficiency. The gain in brake mean effective pressure is about 2 per cent, while the gain in brake thermal efficiency is 9 per cent. Card *b* is a record of a spark-plug test terminating with preignition. The apparently high indicated mean effective pressure of the preignition card cannot readily be explained, since it was accompanied by a loss in brake load. Card *a* shows the effect of spark advance at low output. The record performance of cards *c* to *f* was attained with poppet valves of the internally cooled type. Such valves have operated satisfactorily at engine speeds as high as 3400 rpm, indicating that valve gears for the present are not a limiting factor in high output per cubic inch. New developments in the line of fuels are making possible higher brake mean effective pressures, and high rotative speeds with ample bearing areas and counterbalancing are actually producing lower unit bearing loads than have recently been the rule in aeronautical engines. The requisite displacement per minute is at present being obtained from cylinders of moderate size. How far it will be possible to go along the present lines before developing new types of power plant is at present not known.



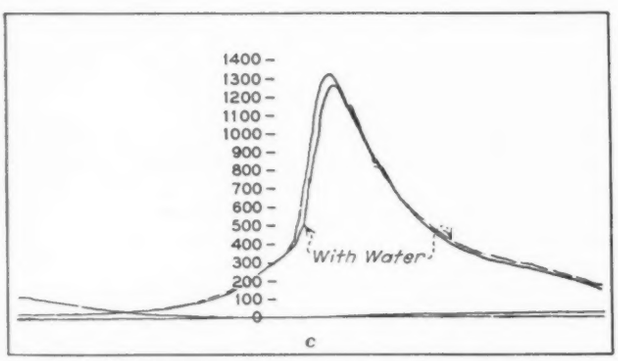
Card *a:* Nonsupercharged engine running at 1900 rpm

Spark advance, deg.....	20	28	40	50	60
Brake mep, lb per sq in..	109	117.5	121.3	119.0	112.3

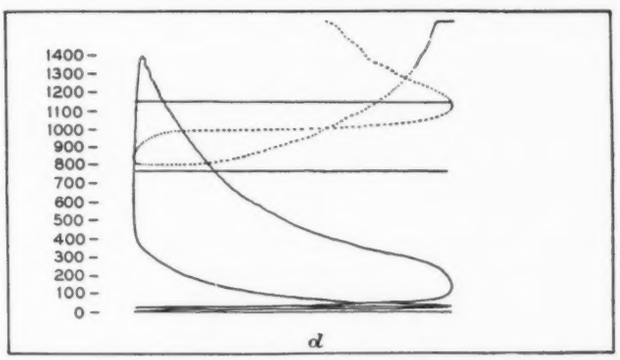


Card *b:* Supercharged engine running at 1900 rpm, 300 F jacket water

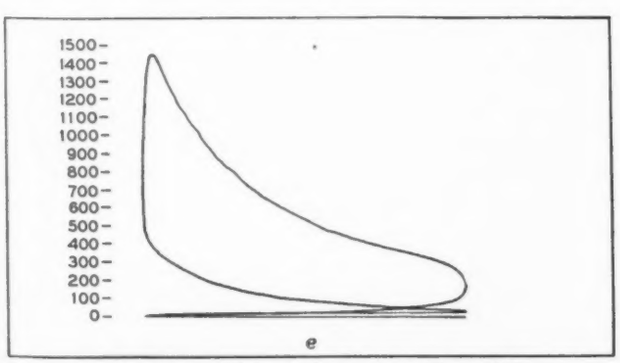
Supercharger pres., in. Hg	10.5	13.6	16.7	20.4	24.3	38.3	30.1
Brake mep, lb per sq in.	185	202	219	243	270	296	309



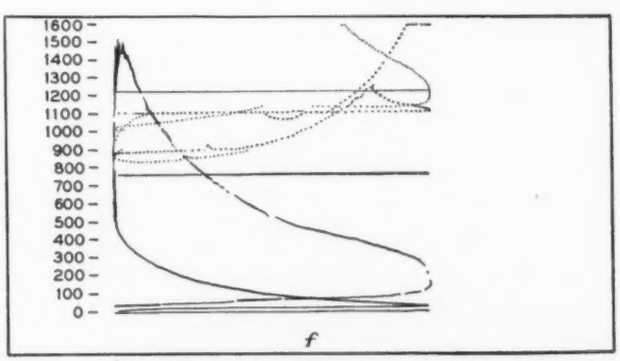
Card *c:* Effect of knock suppression by water injection
Without water: 1800 rpm, boost pres. 50 in., 415 + 10 cc lead, brake mep 427 lb per sq in., fuel 0.547 lb per hp-hr.
With water: 1800 rpm, boost pres. 51 in., 4.15 + 10 cc lead, brake mep 442 lb per sq in., fuel 0.498 lb per hp-hr, water 0.127 lb per hp-hr.



Card *d:* Weak-spring card at 494 brake mep
1890 rpm, brake mep 494 lb per sq in., spark advance 29 deg, fuel 0.486 lb per hp-hr, water 0.217 lb per hp-hr, boost pres. 61.5 in., barometer 29.34 in., 138.6 bhp.



Card *e:* High cylinder performance, stable conditions
1900 rpm, brake mep 539 lb per sq in., spark advance 29 deg, fuel 0.478 lb per hp-hr, water 0.237 lb per hp-hr, boost pres. 72 in., barometer 29.34 in., 152 bhp.



Card *f:* High cylinder performance, unstable conditions
1800 rpm, brake mep 579 lb per sq in., spark advance 27 deg, fuel 0.506 lb per hp-hr, water 0.1435 lb per hp-hr, boost pres. 75.8 in., barometer 29.46 in., 154.7 bhp.

FIG. 9 INDICATOR CARDS—HIGH-OUTPUT POPPET-VALVE CYLINDER

THE A.S.M.E. MEMBER'S JOB

Survey Shows More Than 55 Per Cent Are Engaged in Manufacturing, 12 Per Cent in Professional Services, and 10 Per Cent in Education

ABOUT a year ago, by the direction of the Council of The American Society of Mechanical Engineers, a four-page questionnaire was sent to every member of the Society, asking for biographical and professional data on the basis of which a more effective service could be rendered by all groups engaged in Society work. The total number of returns received up to the time attempts were made to analyze the results was 6976, or approximately 50 per cent of the members in good standing at that time. The purpose of the present report is to review the objectives toward which the questionnaire was directed and to publish such results as have been obtained.

The need for the data requested is fairly obvious. Biographical and professional data are secured when applications for membership in the Society are filed. No formal means of keeping these records up to date have been developed, except at times when some emergency or special need develops. Such an occasion was faced during the World War, when the Society undertook to classify its membership in order to have on file experience records from which names of men could be quickly located for some specific service in the national emergency. Again, in 1930, when it was decided to make a survey of the earnings of mechanical engineers, statistics relating particularly to this question were gathered and analyzed. A more extensive survey, recently conducted by the U. S. Department of Labor, under the leadership of the American Engineering Council, and covering all engineers, regardless of Society affiliation, and for the purpose of inquiring into conditions of employment, was also conducted last year, although the results, as noted in MECHANICAL ENGINEERING for February, 1936, pages 74 and 134, are not as yet available.

WHY THE DATA WERE GATHERED

Five years of depression have had serious effects on individuals and on Society policy and programs. During these years more than the usual changes and dislocations of employment have taken place. Many A.S.M.E. members are engaged in work quite different in nature and function from what they had known in better times. Many are in need of positions; others can be more effectively employed if the man and the job can be brought together. The 1935 data are particularly helpful in meeting this situation and have been so used already. Society policies and programs are under revision and review, and without a fairly clear picture of the kinds of industries in which the members of the Society are engaged, and the functions these men perform in industry, no intelligent planning is possible. Furthermore, the work of the Society itself depends upon its committees, and these are recruited from the membership. The data now on hand have already provided the Society's officers and committee chairmen with valuable information on individuals eligible for this type of service and willing to undertake it. Member interest in professional and technical subjects to which the meetings, the activities of the professional divisions, and the publications are directed, has been established by the preferences which the questionnaire brought forth. And lastly, the biographical as well as the professional data provide authoritative material for that final obligation which the Society discharges to all its members, a memorial notice of his life and achievements published in the Society Record after his death.

WHAT KINDS OF DATA WERE REQUESTED

It was with these objectives principally in mind that the questionnaire was set up. The form consisted of four pages, $8\frac{1}{2}$ by 11 inches, containing 40 items upon which data were desired and printed in such a manner that it could be filed for constant reference. The returned questionnaires are so filed.

The first page provided space for biographical data. The first ten items related to the member's name and address, his work and position, and his Society status. Six items of biographical data were devoted to his family and citizenship, and six others to his education and the states in which he is licensed to practice.

On the second page an opportunity was provided for the member to indicate the interests he has in the subject matter covered by the professional divisions of the Society, and his personal interests in engineering equipment.

Page three contained a space in which the member could report chronologically all of his professional engagements, the firms he has served, and the positions he has held. Space was also found for a photograph, and for the listing of special interests not mentioned elsewhere.

The fourth page provided for the listing of specialties engaged in by consulting engineers; for awards, prizes, and medals received; for the titles of papers and books; for membership in societies and civic bodies; and for public offices held and military service rendered.

STATISTICAL RESULTS OF ANALYSIS

Obviously, only a portion of the data recorded on these questionnaires can be treated statistically; and to date the statistics analyzed relate only to industrial and functional classifications, to interests expressed by the member in the subjects covered by the professional divisions, to the character of committee service he would be willing to render, and to the branches of engineering in which he may practice as a consulting engineer and in which he is a specialist.

For purposes of classification, the 6976 replies were sorted into the following industrial groups:

Classification	Number	Per cent
Metal manufacture	486	6.90
Machinery manufacture	2196	31.50
Manufacturing, nonmetallic	1212	17.40
Public utilities	614	8.80
Transportation	204	2.95
Extractive industries	90	1.30
Construction	263	3.75
Professional services	833	11.95
Education	691	9.90
Commercial and nonengineering, including sales	387	5.55
Total	6976	100.00

TABLE 1 INDUSTRIAL AND FUNCTIONAL CLASSIFICATIONS OF 6976 A.S.M.E. MEMBERS, 1935

METAL MANUFACTURE, 486

Product		*Function*	
Rolled-steel shapes	75	General administration	63
Pipe and tubes	50	Staff personnel	2
Forged-steel products	37	Design or testing supervision	66
Foundry (ferrous and nonferrous)	81	Design, testing, or research	92
Sheet-metal products	129	Production supervision	89
Precious or ornamental metal	12	Production	129
Nonferrous (rolled and extruded)	63	Commercial supervision	10
Wire and wire rope	39	Commercial (incl. sales)	35
Total	486	Total	486

MACHINERY MANUFACTURE, 2196

Product		*Function*	
Machine tools (including presses)	120	General administration	257
Special tools, dies, gages, etc	65	Staff personnel	18
Mechanisms and light machinery (office machinery, clocks)	174	Design or testing supervision	415
Specially designed light machinery	209	Design, testing, or research	621
Machinery accessories, bearings, transmissions, etc	114	Production supervision	273
Boilers, boiler-plant equipment, steam prime movers	217	Production	276
Hydraulic machinery, turbines, pumps, etc	235	Commercial supervision	93
Internal-combustion engines	81	Commercial (incl. sales)	243
Railroad, equipment, steam, electric, locomotives, cars	92	Total	2196
Automotive, aeronautic (engines and accessories)	174		
Heating, ventilating, air-conditioning, refrigeration	190		
Process or chemical industry machinery	103		
Heavy machinery	237		
Electrical equipment (incl. motors, generators, etc.)	185		
Total	2196		

(*Table 1 continued in next column*)

MANUFACTURING NONMETAL INDUSTRIES, 1212

Product		*Function*	
Textiles, clothing, and cordage	122	General administration	88
Lumber, furniture, and woodworking	49	Staff personnel	22
Clay, glass, tile, and stone industries, opticals, cameras	144	Design or testing supervision	148
Food, drug, beverage, and tobacco industries	175	Design, testing, or research	202
Chemicals, paints, petroleum, paper, and paper products	582	Production supervision	249
Rubber, leather, boots, and shoes, fabric packings	67	Production	405
Printing	30	Commercial supervision	29
Linoleum, cord products, cellulose products	42	Commercial (incl. sales)	69
Total	1212	Total	1212

PUBLIC UTILITIES, 614

Product		*Function*	
Electric light and power	452	General administration	18
Gas	81	Staff personnel	10
Steam	27	Design or testing supervision	66
Telegraph and telephone, radio and cable	34	Design, testing, or research	111
Water supply	20	Production supervision	154
Total	614	Production	196
		Commercial supervision	11
		Commercial (incl. sales)	48
		Total	614

TRANSPORTATION INDUSTRIES, 204

Type		*Function*	
Steam railroad	108	General administration	13
Electric railroad	17	Staff personnel	3
Water-borne	21	Design or testing supervision	19
Automotive	22	Design, testing, or research	33
Aeronautical	15	Production supervision	47
Pipe-line	21	Production	82
Total	204	Commercial supervision	3
		Commercial (incl. sales)	4
		Total	204

EXTRACTIVE INDUSTRIES, 90

Product		*Function*	
Coal	30	General administration	4
Copper, lead, and zinc	22	Staff personnel	0
Iron and steel	6	Design or testing supervision	19
Oil and gas	26	Design, testing, or research	13
Nonmetallic minerals	6	Production supervision	20
Total	90	Production	23
		Commercial supervision	4
		Commercial (incl. sales)	7
		Total	90

CONSTRUCTION, 263

Type		*Function*	
General building construction	72	General administration	39
Municipal construction, streets, sewers, highways, etc	66	Staff personnel	1
Railroads, steam, electric trolley, subways, etc	7	Design or testing supervision	31
Harbors, rivers, piers, canals, dams, bulkheads, etc	18	Design, testing, or research	51
Foundations, piling, retaining walls, etc	2	Production supervision	50
Bridges	9	Production	70
Building trades; electric, plumbing, heating and ventilating, etc	30	Commercial supervision	10
Steamships and boats	37	Commercial (incl. sales)	11
Miscellaneous	22	Total	263
Total	263		

Each of these major groups was broken down into several industrial subgroups, and within each a functional classification was attempted. The results are listed in Table 1.

The terms used in the functional classification need some elucidation. An attempt was made to distinguish between functions that are preeminently supervisory, and those that are not. To this first group belong "general administration," which includes administrative officers, presidents, managers, etc.; "design and testing supervision;" "production supervision;" and "commercial supervision." To the second group belong "staff personnel," "design, testing, and research," and "production." Under such a classification, the results are as indicated in Table 2. Attempts at analyzing professional-service, educational, and commercial and nonengineering classifications into functions as was done for the others was abandoned as it became evident that they had little significance.

From the 6976 questionnaires returned, 1450 members indicated that they had not served, or would be willing to serve, on committees. The statistics are summarized in Table 4. In addition to the data presented in Table 4, 661 members not included in the table reported that they had served, or are now serving, on committees of the Society.

Table 1 (continued)

PROFESSIONAL SERVICES, 833

Type	
Engineers	551
Architects	13
Patent experts	36
Army and Navy	80
Government	153
Total	833

EDUCATIONAL, 691

Type	
Colleges and universities	575
High and vocational schools	63
Museums	4
Publications	39
Religious institutions	10
Total	691

COMMERCIAL AND NONENGINEERING, 387

Type	
Banking and finance	19
Insurance	79
Warehouses	5
Sales agencies	185
Real estate	26
Accountants	5
Prof. and trade associations	26
Miscellaneous	42
Total	387

TABLE 2 SUPERVISORY AND NONSUPERVISORY FUNCTIONS

Group	Number	Per cent
Supervisory	2287	45.10
Nonsupervisory	2359	46.65
Commercial and nonengineering, including sales	419	8.25
Total	5065	100.00

Another grouping that divides the membership roughly into thirds is attempted in Table 3. Here a distinction is made between those in design, testing, and research, and those in production.

In indicating interest in the subject matter covered by the professional divisions, each member was asked to check as many as he chose, and to give, if he so desired, the order of his preference. From the data already analyzed Table 5 was prepared.

TABLE 3 GENERAL INDUSTRIAL CLASSIFICATIONS

Classification	Number	Per cent
Design and testing	2185	31.2
Production	2342	33.5
All others	2449	35.3
Total	6976	100.0

TABLE 4 COMMITTEE SERVICE

ADMINISTRATIVE COMMITTEES

Council	3
Finance	3
Junior	8
Local Sections	25
Membership	3
Meetings and Program	1
Patents	4
Publications	4
Relations With Colleges	12
Total	63

PROFESSIONAL DIVISIONS AND TECHNICAL COMMITTEES

Aeronautics	16
Applied Mechanics	6
Boiler Code	12
Fuels	23
Hydraulics	17
Iron and Steel	9
Lubrication	10
Machine Shop Practice	25
Management	83
Materials Handling	13
Oil and Gas Power	24
Petroleum	14
Power, Steam	53
Process Industries	32
Railroad	25
Research	41
Standardization	33
Textiles	7
Miscellaneous	24
Will serve on any committee	68
Select more than one committee	94
Served in other Societies but not in A.S.M.E.	97
Total	726

TABLE 5 ANALYSIS OF CHOICES BY DIVISIONS

	First choice				Total	
Division	No.	Per cent	Second	Third	No.	Per cent
Aeronautic	168	4.55	98	135	401	4.15
Applied Mechanics	327	8.88	375	301	1003	10.39
Fuels and Steam Power[1]	843	22.90	461	299	1603	16.6
Hydraulics	162	4.39	170	218	550	5.7
Iron and Steel	120	3.26	136	200	456	4.75
Machine Shop Practice	402	10.91	447	316	1165	12.2
Materials Handling	57	1.55	155	174	386	4.0
Management	800	21.70	509	361	1670	17.3
Oil and Gas Power	149	4.05	297	319	765	7.8
Petroleum	109	2.96	74	79	262	2.72
Graphic Arts	48	1.31	28	29	105	1.09
Process Industries	337	9.14	228	283	848	8.8
Railroads	87	2.36	59	61	207	2.16
Textiles	44	1.20	41	36	121	1.26
Wood Industries	31	0.84	32	41	104	1.08
Total	3684	100.00	3110	2852	9646	100.00

[1] These two divisions are here combined, but were separated on the questionnaire.

As pointed out in the foregoing article, all questionnaires returned to the headquarters are in a permanent file where they are consulted daily for the purpose of finding men who can serve on committees, who can be recommended for appointment to government commissions and positions, for consulting and educational work, and for positions in industry that come to the attention of the Society's officers. Members who have not sent in their questionnaires are asked to do so in order that they may be placed on file.—EDITOR.

SEIZURE OF METALS *at* ELEVATED TEMPERATURES

And Methods of Testing for Propensity Toward Seizure

ONE of the causes of failure of metals at high temperature is seizure, the incipient welding together of two metal surfaces in contact. If it were possible to produce absolutely matching surfaces so that all atoms in one surface come within the sphere of influence of the atomic forces of corresponding atoms in the other surface, welding would occur at room temperature where the surfaces are brought together. Optical-glass flats of sufficiently high perfection brought together without any intervening film do adhere and cannot be separated without roughening and ruining the surfaces. Similar care has to be used in wringing together steel gage blocks with extremely plane surfaces. Perfect molecular contact is conducive to welding of solid metals.

The relative crystal structure of the two metals, their ease of alloying with each other, and their ability to diffuse into each other enter into the problem of solid weldability. A metal is usually readily weldable to itself. A hole in a platinum crucible may be welded by placing a platinum patch over it, heating to drive out adsorbed gas films and bringing the pieces together under moderate pressure at temperatures far below the melting point. Gold and lead, of like crystal structure, readily diffuse into each other when in contact under pressure, even at room temperature. Broadly speaking, the more dissimilar the two metals are, the better they resist seizure.

While perfectly matching surfaces will weld readily, in order to bring surfaces of ordinary smoothness of finish into molecular contact it is usually necessary that one surface at least be fairly plastic and be pressed against the other so as to force them into molecular contact. In many such cases plasticity is brought about by elevated temperature so that the seizure problem is quite generally a high-temperature problem.

When both surfaces have the same hardness in all parts, mutual flow under plastic action probably makes toward a more perfect fit, while a difference in hardness, or the presence in one or both surfaces of a second phase, say, as small hard particles, tends to prevent a perfect fit and hence to prevent seizure. If the difference in hardness is too great, the harder metal may tend to penetrate the softer and cut it, so there is a limitation in this respect. The work-hardening propensities of the metals also come into play, since hardening produced by pressure and initial deformation may serve to resist further deformation.

Alloys of heterogeneous structure generally are more resistant to seizure than metals of a like range of hardness but of uniform or homogeneous structure. Thus, pure metals and solid solutions are in general less wear-resistant than metals containing structural discontinuities—either compounds (e.g., nickel-silicide) eutectics or eutectoids (e.g., copper-tin eutectoid in high-tin bronzes), or discrete particles (e.g., lead in bronze, graphite in gray iron).

Unless they are soluble in the solid metal at the temperature in question, oxide or other nonmetallic films prevent metallic contact of the coating surfaces and may thus prevent seizure. A film of oil, or even of adsorbed gas, will likewise prevent contact. Seizure is prone to occur when one metal plows through another with a cutting action and rubs off any surface film to bare absolutely clean metal. An enlightening discussion by Tomlinson[1] of the phenomenon of powdery red rust from steel surfaces in contact under pressure and slight relative movement, especially a reciprocating movement, shows that the true cause is local seizure, the tearing off of tiny particles which are so small that they oxidize spontaneously. Relative motion is practically essential for seizure.

A turning tool may pick up upon its tip a welded button of the metal cut.

When soft-steel pipes are threaded together with tightly fitting threads so that the threads tend to gouge each other and bare fresh surfaces or scrape off any surface film, seizure, or its beginning, "galling" (in which pellets or streaks from one surface adhere to the other), may ensue. Wire drawn through a die without proper lubrication may gall the die.

To prevent such galling a film of iron rust (sull coat), lime, or lead may be used to keep the surfaces from actual contact despite the pressure. Oxide films, produced during relative motion, have an effect upon wear and seizure. While they persist they tend to prevent contact, but they may grow to such thickness that they spall off all at once, baring a clean surface, and this may be conducive to seizure. Films produced by corrosive media might conceivably be seizure preventives, but are usually of such type that they are removed by relative motion of the parts. A corrosion-roughened surface is usually in a condition leading to high local pressure at promontories.

Lead, in a threaded joint, or as a wire-drawing lubricant, probably serves to prevent galling because of its lack of solubility and diffusibility in steel. The presence of oxide films is not a sure preventive of seizure. Graphite films from cast iron generally prevent seizure. Cast iron may cut, but it seldom seizes.

The temperature required to give the plasticity that will result in seizure may be locally generated at promontories that take excessive pressure, under relative motion. If the nature of the metal allows prompt distribution of stress, the local pressure may be relieved before seizure occurs. Preliminary wearing-in at low pressures may thus raise the pressure at which metals seize. On the other hand a perfect "optical"

Condensed from a progress report, by Subgroup N on Wear and Seizure, to the A.S.T.M.-A.S.M.E. Joint Research Committee on Effect of Temperature on the Properties of Metals. Presented at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The personnel of Subgroup N is as follows: J. W. Bolton, Chairman, Chief Chemist and Metallurist, The Lunkenheimer Company, Cincinnati, Ohio; J. W. Maack, Chief Chemist and Metallurgist, Crane Company, Chicago, Ill.; R. Sergeson, Republic Steel Corporation, Massillon, Ohio; E. K. Smith, Stockham Pipe & Fittings Co., Birmingham, Ala.; and W. A. Wissler, Union Carbide and Carbon Research Laboratories, Niagara Falls, N. Y.

[1] "The Rusting of Steel Surfaces in Contact," by G. A. Tomlinson, Proceedings, Royal Society of London, vol. 15, 1927, p. 472.

FIG. 1 SEIZURE OF LEAD ON LEAD, LUNKENHEIMER TEST METHOD
(The metal has flowed and smeared way beyond the original surfaces of contact. Adhesion was similar to that of taffy on taffy.)

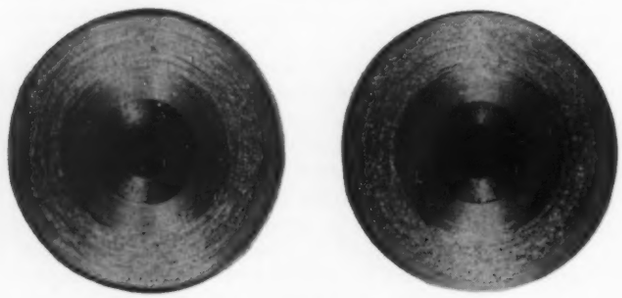


FIG. 2 ALUMINUM ON ALUMINUM

finish should tend toward seizure. In general a reasonably smooth pair of mating surfaces is preferred for cases of unlubricated contact, but the optimum finish is a matter of dispute and calls for research.

The chief requirement for seizure, thus, is contact (freedom from intervening films), which arises from relative motion, pressure, and plasticity. Plasticity arises from pressure and elevated temperature (ambient or local). The tendency to adhere, a type of chemical action, also increases with temperature, as does chemical activity in general. Given contact, the type of metal is of importance. Homogeneous, single-phase, plastic metals, such as pure lead, aluminum, and many of its alloys, alpha copper-nickel, soft iron, low-carbon stainless steels, and 60–40 yellow brass without lead, seize readily against themselves, and in some cases against other homogeneous metals.

Metals of heterogeneous structure and of local variability in the hardness of their constituents which are resistant to seizure are nitrided steel, with its hard surface, largely nonmetallic; gray cast iron; some steels of high hardness; certain duplex nickel-copper-tin alloys; and leaded bronze.

Leaded bronzes not only operate well against other metals such as steel, but those fairly low in lead operate well against each other, even at 750 F. The freedom from seizure may be even greater when such an alloy operates against itself than against another metal.

The phenomena of galling and seizure are illustrated in Figs. 1 to 8, which are described in their captions.

Seizure is of particular moment in sleeve bearings and in valves operating at high temperatures. In the first case the temperature is produced by friction, in the second by the heat of the material passing through the valve. In the first a lubricant is present and has to be displaced before seizure can occur; in the second, especially in the case of superheated steam, no lubricant is present.

Some information on propensity toward seizure can be obtained from certain types of bearing testers. The Amsler bearing-testing machine, operating with one fixed specimen which has a circular arc cut in its periphery, into which arc the other cylindrical-disk specimen fits, as illustrated by French,[2] may be so used. The dynamometer pendulum of the machine registers the torque and indicates incipient seizure as the pressure is stepped up to the seizure point. For bearing-metal studies, the machine is normally operated at room temperature, but the specimens may be enclosed in a small electric furnace and the tests made at elevated temperatures. The machine was not designed for use at elevated temperatures, and the space for the heating furnace is limited. Other types of bearing testers give some information as to failure by seizure or "wiping," which may be allied to seizure, but seizure data on bearing metals are too scanty to afford grounds for generalization.

The seizure problem is especially acute with the makers and users of valves for high-temperature service, and most of the available test data relate to experiments planned to evaluate properties for such service. The most comprehensive discussion on record is that of Mochel,[3] who described his test equipment and reported tests on 25 alloys at 750 F, using 235 rpm, a 20-lb load upon a specimen $1\frac{1}{4}$ in. in diameter, whose working face was ground spherical to $\frac{7}{8}$-in. radius and fitted into a $\frac{7}{8}$-in. radius spherical socket in the other specimen, or upon a flat-disk specimen, 1 in. in diameter, working against a flat surface. The spherical-seat type of specimen was designed to avoid trouble from canting of flat specimens, but the flat specimens were found to give the same indications as spherical ones. One of the coacting surfaces was held stationary, the other rotated against it. The rotating force is transmitted to the specimen through a shaft of 0.02-in. steel wire which shears off when the specimens seize. The specimens are enclosed in an electric furnace. Speeds, pressure (within limits), and temperature can be varied at will. Mochel's aim was to see if his test method would rate materials

FIG. 3 TIN ON TIN
(A pellet has become detached from specimen and attached to the other.)

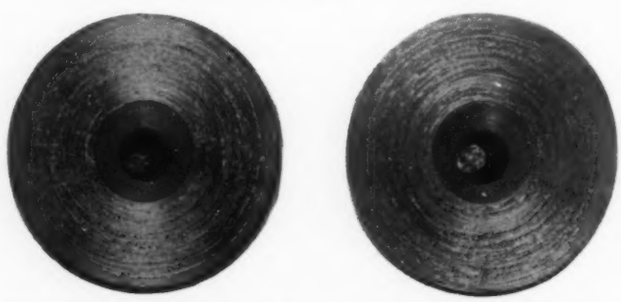


FIG. 4 0.12 PER CENT C, 13 PER CENT CR STEEL ON ITSELF

[2] "Wear and Mechanical Tests of Some Railroad Bearing Bronzes," by H. J. French, Proceedings, A.S.T.M., vol. 28, part 2, 1928, p. 298.
[3] "The Seizing of Metals at High Temperatures," by N. L. Mochel, Proceedings, A.S.T.M., vol. 28, part 2, 1928, pp. 269–275.

as to seizure in the order in which they had been observed to fall in practice, and he concluded that it did so.

One particularly interesting finding by Mochel was that while stainless iron seized readily against itself, with both specimens of the same hardness, when one of the specimens was annealed (180 Brinell) and the other quenched and tempered (223 Brinell), seizure did not result, but excessive wear did result and the wear was the greater upon the harder specimen. Cast iron and nitrided steel were notable in the variety of other materials against which they would operate without seizure.

Spring[4] reported having tried pulling a flat specimen of material to be tested for seizing tendencies along a flat plate to which it was held by spring pressure, the motion being produced in a testing machine, but he decided that it was desirable to have reciprocating motion and control of temperature, as well as to be able to work in any atmosphere desired. In the special testing machine illustrated by Spring to meet these requirements a flat wearing plate, which can be considered as one specimen, is moved back and forth in the same plane by a crank arm at speeds up to 5 cycles per minute. The wearing plate is inset in the moving bed, which is supported on rollers, the bed moving through slots in the electric furnace surrounding the test specimens. The other test specimen is a flat-faced ring resting on the wearing plate and held against it by dead-weight loading, adjustable at will. The seat for the ring specimen is hollow so that steam or other desired atmosphere can be injected through a pressure line upon the interface of the wearing surfaces. The outfit is designed to operate up to 1000 F and 8000 lb per sq in. pressure. These conditions will produce seizure upon all but the hardest materials. Flatness of test specimens is required and is obtained by finishing them on a surface grinder. After assembly of the specimens the guide rollers under the moving bed are adjusted so that the specimens will remain level while the machine is in operation. The tractive force between plate and disk is measured by a spring compression indicator and chart and affords a means of following the "wearing in" process, the satisfactory operating range, and the beginning of seizure.

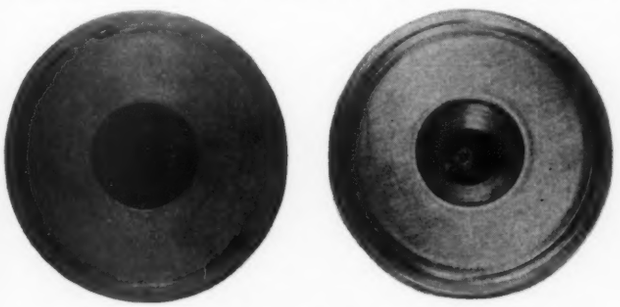


FIG. 5 MACHINERY STEEL ON ITSELF
(Pellets are gathering on one specimen but have not yet been picked up by the other.)

FIG. 6 LEADED BRONZE RUN ON ITSELF AT 750 F WITHOUT SEIZURE

[4] "Considerations and Tests for Cast Materials for High-Temperature, High-Pressure Service," by L. W. Spring, Trans. and Bull., American Foundrymen's Association, vol. 2, October, 1931, pp. 13–55.

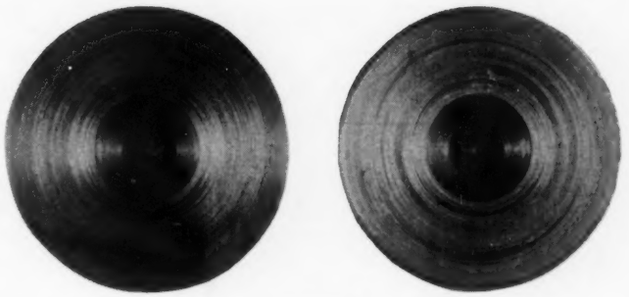


FIG. 7 BRONZE AGAINST STEEL AT 750 F
(The steel is scored, and material removed from it has collected into a pellet which is sticking to the bronze.)

FIG. 8 GRAY CAST IRON, SCARCELY AFFECTED BY RUNNING ON ITSELF AT 750 F

No detailed results of tests performed with this machine have been published, but Spring drew the following generalizations: Hardness is a major factor in resisting scoring; the presence of hard, intermetallic compounds is helpful; and coarse-grained cast alloys are more resistant than the same alloys in wrought or finer-grained condition.

It has also been found that seizure is less drastic in superheated steam than in air at the same temperature and pressure.

An outfit which has not been previously described was devised by Bolton. A flat-faced test "head" specimen (Fig. 9) is keyed onto a rotor shaft which is turned 120 deg in one direction, and then reversed through 120 deg at about one complete cycle in 2 min. The moving specimen (1 in Fig. 10) is pressed against another flat-faced "floating" specimen (2 in Fig. 10), which is carried on a spherical seat to avoid trouble from canting. The floating specimen is pressed against the moving specimen by a floating arm provided with roller bearings and a thrust roller bearing, and the pressure it causes to be exerted between the moving and the stationary specimens can be adjusted at will and is measured by a "proving ring" device. Friction between the two specimens can be measured by spring balances attached to a rod passing through the floating arm. The outfit has been found suitable for operation at both high and low loads. The specimens are enclosed in an electric furnace which can be operated up to 1200 F. Any desired atmosphere can be used by jacketing the furnace.

Spring's and Bolton's devices are designed to allow higher unit pressure than Mochel's and to use reciprocating rather than pure rotary motion in one direction only. It would be of interest to have a series of typical valve-seat and disk mate-

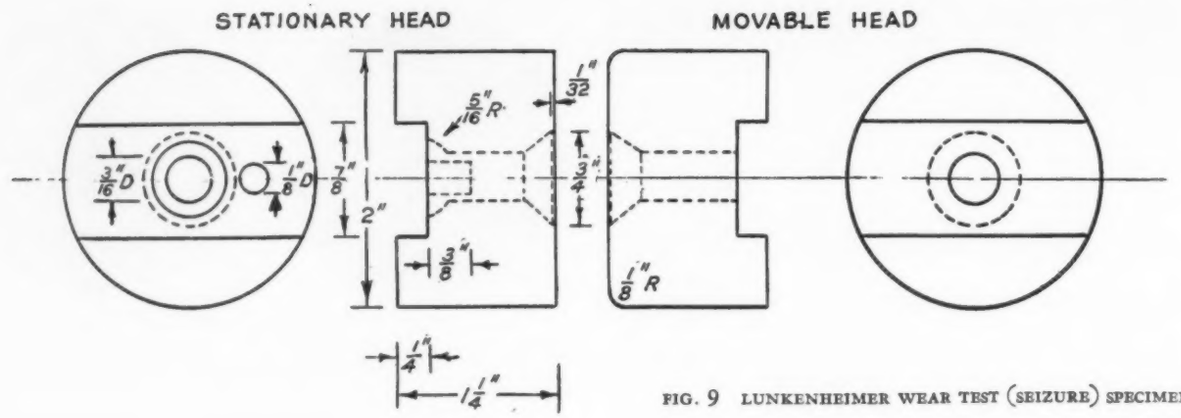


FIG. 9 LUNKENHEIMER WEAR TEST (SEIZURE) SPECIMENS

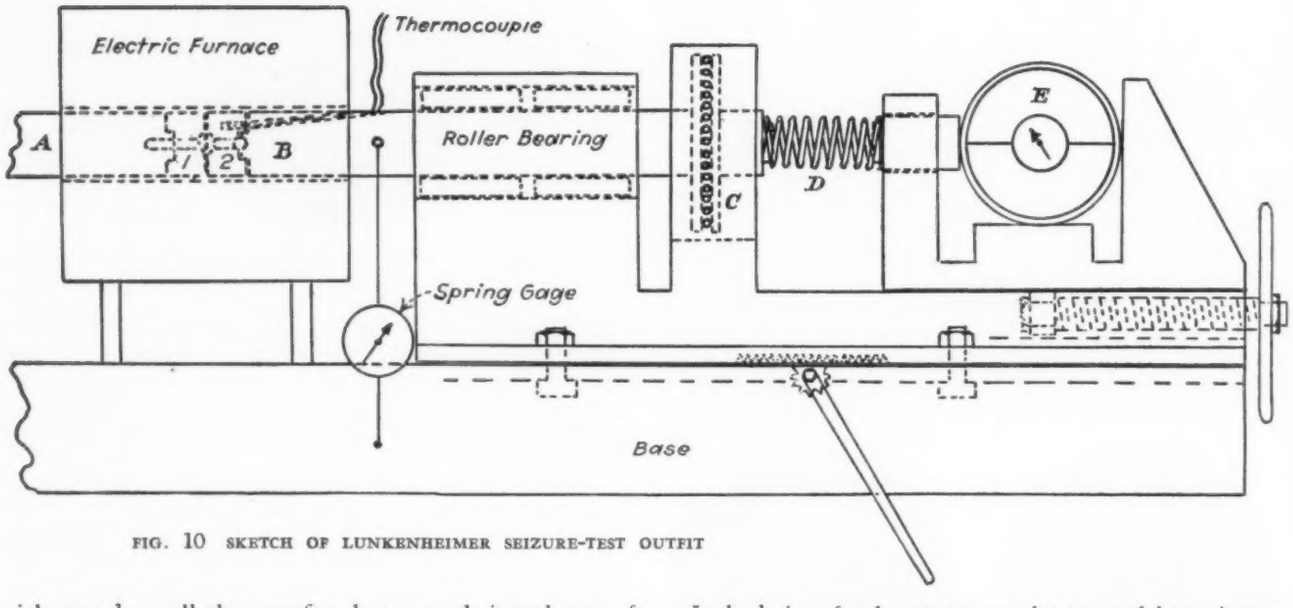


FIG. 10 SKETCH OF LUNKENHEIMER SEIZURE-TEST OUTFIT

rials tested on all three outfits, but no such interchange of specimens has yet been undertaken. Each outfit is reported to have given a fair evaluation of the seizing propensities of the alloys studied, but without some corroborative service experience, none of them is expected to give so complete an evaluation of all the variables that can be met in practice as to make it safe to rely upon its indications alone.

Besides these laboratory testing outfits, some of the valve makers have carried on simulated service tests on actual, completely assembled valves, heavily insulated, which were opened and closed with full pressure (superheated steam up to as high as 900 F) on one side and atmospheric pressure on the other. Results of such tests are, however, not as yet available for publication.

There would appear to be a field for a simple device that will give preliminary indications of the suitability of a new alloy for seizure resistance even though it does not allow covering all the variables present in service. In this connection it would be of interest to know whether rotary motion, as in the Amsler and in Mochel's device, will serve or whether reciprocating motion is required.

There seems also to be a field for a more elaborate outfit of the types used by Spring and by Bolton, in which the ranges of pressures, atmospheres, and relative motion as in severe-duty valves for use at the highest temperatures may be used.

In the design of such an apparatus cheapness of the equipment, cost of preparing specimens, ease of operation, and reproducibility of results should be considered. Since only two such outfits are known to have been constructed, and these differ in the means of controlling the variables, the ultimate design of such equipment is not settled.

The construction and use of both types of equipment in the evaluation of a group of materials would appear to be a fruitful line of effort for graduate mechanical-engineering theses, and offers interesting possibilities for cooperation between mechanical-engineering and metallurgical-engineering groups in universities or elsewhere. The field is not untouched, since valve makers have tilled it to some degree in order to improve their products, but information available for publication and for the information of the general engineering public is meager.

The importance of this problem to engineers who have to deal with high-temperature service, in which seizure may occur and in which wear is worth while avoiding, would seem to justify more attention from the point of view of the user than it has yet received. This condensation of the subcommittee's report is presented in the hope of crystallizing thought on the problems in this field and to afford a means of inviting from industry further information on existing data, ideas regarding the usefulness of work by the Joint Research Committee in this field, and suggestions as to a detailed program for such work.

ALUMINUM CONNECTING RODS

An Investigation of the Stress Distribution

By R. L. TEMPLIN

CHIEF ENGINEER OF TESTS, ALUMINUM COMPANY OF AMERICA

LIMITATIONS of available space in the main driving wheels of large freight locomotives frequently preclude the provision of desired amounts of counterbalance weight when using the ordinary types of steel rods. While various methods of cross balancing have been used, it would seem that considerably more gain would be made if lighter rods could be used on such locomotives. In view of the marked advance made in the development of large aluminum-alloy forgings, it would seem that a suitable material might be found in this field. It should be pointed out that aluminum-alloy connecting rods have been in use experimentally for a number of years with quite satisfactory results. The forging alloy used, designated as 25S-T, has the following nominal composition: Copper 4.4 per cent; silicon 0.8 per cent; and manganese 0.75 per cent; the remainder being aluminum. Extensive tests have been carried out on the metal in the form of large side-rod forgings and the mechanical properties indicated in Table 1 obtained.

The successful use of a new material in the design of locomotive connecting rods depends upon three factors: (1) A knowledge of the mechanical properties of the material; (2) a reasonable knowledge of the service conditions to which the rods will be subjected; and (3) a knowledge of the stress distribution produced in a rod of given proportions under a known loading condition.

The investigation briefly described in this paper has been confined to an experimental study of the latter problem. The work has included laboratory tests on 15 models of the eye-bar type, tests on a full-size aluminum-alloy connecting rod; tests on a model of the new design of a particular rod; and field tests on some rods on a heavy-duty engine under actual service conditions.

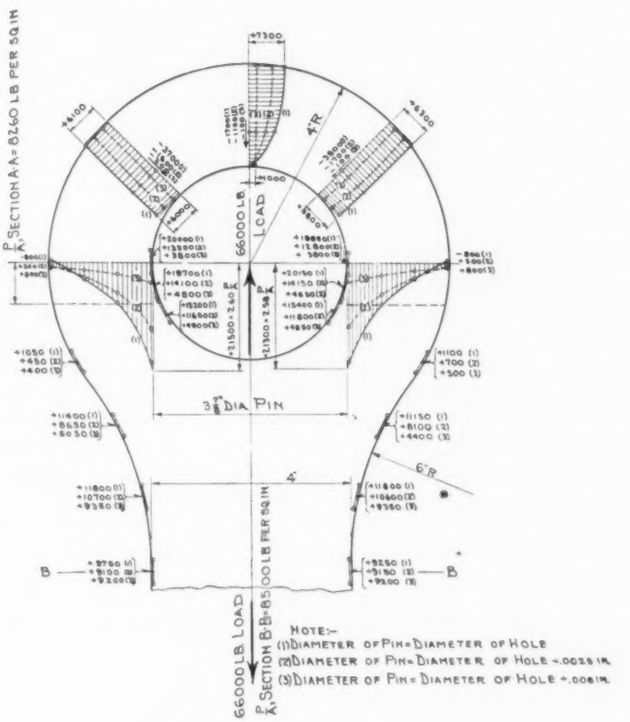

P, SECTION A-A = 8260 LB PER SQ IN
66000 LB LOAD
4"R
3 1/2" DIA PIN
6"R
4"
P, SECTION B-B = 8500 LB PER SQ IN
66000 LB LOAD
NOTE:-
(1) DIAMETER OF PIN = DIAMETER OF HOLE
(2) DIAMETER OF PIN = DIAMETER OF HOLE - .0028 IN.
(3) DIAMETER OF PIN = DIAMETER OF HOLE - .008 IN.

FIG. 1 MEASURED STRESSES IN EYE-BAR NO. 5

TABLE 1 MECHANICAL PROPERTIES OF 25S-T LOCOMOTIVE MAIN-ROD FORGINGS

Section	Orientation of specimen[1]	Tensile strength, lb per sq in. Min	Tensile strength, lb per sq in. Avg	Yield strength,[2] lb per sq in. Min	Yield strength,[2] lb per sq in. Avg	Elongation, in 2 in., per cent Min	Elongation, in 2 in., per cent Avg	Brinell hardness Min	Brinell hardness Avg	Endurance limit, lb per sq in.
Shank	L	55300	56260	34600	36040	16.0	19.0	107	112	13000
Crosshead end	L	55400	56440	35000	35970	16.0	18.7	107	112	12000
Crankpin end	L	52700	55370	32300	35020	11.5	16.2	107	113	12500
Shank	T1	53800	55465	34000	35600	10.0	11.6	...	...	13000
Crosshead end	T1	55500	56365	35600	36000	10.5	11.8	...	...	14000
Crankpin end	T1	50200	52750	31800	34050	8.0	11.1	...	...	11500
Shank	T2	56400	56865	35300	35800	11.0	11.6	...	...	...
Crosshead end	T2	54500	54800	33700	34200	12.0	12.5	...	...	...
Crankpin end	T2	51900	53635	32300	33500	9.0	10.7	...	...	12000

[1] L = Longitudinal
T1 = Transverse parallel to plane of web
T2 = Transverse normal to plane of web
Poisson's ratio is 1/3.

[2] Stress for a set of 0.2 per cent.

NOTE: All tensile values obtained using standard A.S.T.M. 1/2-in. diameter specimens.
Shearing strength of 25S-T is 35,000 lb per sq in.
Young's modulus of elasticity is 10,000,000 lb per sq in.

In the tests on the eye-bar models, consideration was given to the effects of four variables: (1) The distribution of material around a simple circular hole; (2) press and loose fits of the pin in such members; (3) different types and kinds of fillers in a rectangular hole with round ends; and (4) variations in length of side section in rectangular openings with round ends. The width of the pin ends of the models ranged from $1\frac{1}{3}$ to $2\frac{2}{3}$ times the diameter of the pin or width of opening, and the

Abstract of a paper contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., Dec. 3–7, 1934, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The complete paper is on file in the Engineering Societies Library, 29 West 39th Street, New York, N. Y.

FIG. 2 MEASURED STRESSES IN MODEL OF ALTON AND SOUTHERN SIDE ROD (TEST NO. 3, LOAD ON MAIN PIN)

thickness of the models ranged from $^1/_4$ to $^1/_3$ the width. All specimens were about three feet long, machined from high-strength aluminum-alloy bar having properties quite similar to those given in Table 1. The models were tested in a hydraulic testing machine of 300,000-lb capacity, the lower or shank end of each specimen being held in the tension grips of the lower crosshead, and the eye end supported on a pin carried in saddles on the upper crosshead. Strain measurements were obtained using Huggenberger tensometers on gage lengths of $^1/_2$ in. for each of a number of different test loads. With these instruments it was possible to measure strains equivalent to stresses of about 80 lb per sq in. in the case of aluminum alloys.

Fig. 1 (same as Fig. 4*A* in complete paper) shows the results of a typical model study. The stress-distribution diagrams shown cover three different conditions of loading: (1) In which the diameter of the pin was equal to the diameter of hole, providing a close fit; (2) in which the diameter of the pin was 0.0025 in. larger than the diameter of the hole, necessitating a press fit; and (3) in which the diameter of the pin was 0.008 in. larger than the diameter of the hole. As will be noted the maximum stresses were found on the inside periphery of the hole near the horizontal section through the center of the pin. The ratio of the maximum stresses at this point to the average for the section gives stress-concentration factors which may be used as a basis for the design of members of this type. For the series of 15 models tested, these stress-concentration factors ranged from 1.20 to 2.68. The lowest values were found in the models having rectangular holes with semicircular filler plugs in the ends. The stress-concentration factors for loose-fitting pins were as much as double those obtained for close-fitting pins. In the case press fits, as indicated in Fig. 1, the measured stress changes under load varied inversely as the ratio of the pin diameter to the diameter of the hole.

The full-sized rod tests were made on an intermediate side rod obtained from an Alton and Southern locomotive after 89,619 miles of service. The stresses were investigated around the main and knuckle-pin ends of this rod, following much the same procedure as described for the model tests. One special feature was the use of a slotted bushing which made possible the measurement of the stresses produced at the edges of the main and knuckle-pin grease outlets. The stresses at these points were found to be approximately double the maximum values measured on the sides of the rod, indicating the desirability of moving these grease outlets to regions of lower stress. The maximum stresses on the sides of the rod, around the inside periphery of the holes, were found to range from two to three times the average computed value for the critical section through the center of the pin, normal to the load.

The tests on the model of the redesigned Alton and Southern rod, previously referred to, were of particular interest because of the two changes made: (1) The width of the shank section was so reduced as to effect a weight saving of about 40 per cent in this part of the rod; and (2) the grease outlets at the pins were all moved from sections of maximum stress to points of comparatively low stress. Fig. 2 (same as Fig. 12*C* in complete paper) shows a typical case of the measured stress distribution for a load on the main pin. The maximum values on the inside edge of the hole averaged about 1.8 times the average computed value for the section through the center of the pin, normal to the load.

The field tests were made on an Alton and Southern 0–10–0 locomotive in cooperation with the University of Illinois and the Alton and Southern Railroad. The dynamometer car jointly owned by the Illinois Central Railroad and the University of Illinois was used throughout the service tests. Complete dynamometer-car records of the usual type were obtained, while stresses were measured on each of the main rods of the locomotive and on two intermediate rods on opposite sides of the locomotive. For making strain measurements, the Baldwin-Southwark-deForest type of recording extensometer was used. The results obtained from these strain measurements indicated that when the locomotive was working at about 80 per cent of its rated tractive effort, the maximum measured stress in the shank section of the main rods was 7900 lb per sq in. The stresses in the main rods were fairly uniform over the entire cross section. The maximum measured stress in the shank section of the rear intermediate rods was 6800 lb per sq in., developed when the locomotive was working at about 90 per cent of its rated tractive effort. The stress on the inside face of the rear intermediate rod was about 50 per cent higher than the stresses on the upper and lower edges of the rod, indicating some bending action. From the results of these field tests a fair estimate of the working loads and their effect on the shank sections of the rods was obtained. These data, used in conjunction with the stress-concentration factors for the pin ends, obtained from the laboratory tests, should make possible a closer determination of the probable maximum stresses occurring in connecting rods of this type in service.

Uses and Limitations of RESPIRATORY *Protective* EQUIPMENT

By PHILIP DRINKER

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PREVENTION of dust inhalation by the wearing of cloths, handkerchiefs, and the like over the nose and mouth was practiced in Agricola's time. Such devices, crude as they were, reduced the discomforts of breathing smoky or dusty air. Although the medieval metallurgists lacked our chemical and medical names for their respiratory hazards, they understood the physiologic effects of carbon monoxide, and Agricola's remarks about silicosis among the Carpathian miners showed that this disease was well known.

The invention of the diving suit by Siebe early in the nineteenth century demonstrated that it was perfectly practicable for a man to breathe air blown to him through a hose connected to a blower some distance away. The modern hose mask and the simpler air-line respirators remind one of Siebe's original equipment.

It was not until the close of the World War, however, that industry in general began to appreciate the industrial possibilities of gas masks, dust respirators, and other respiratory protective equipment. In 1911 the U. S. Bureau of Mines began issuing literature on oxygen-breathing apparatus, but it was not until 1919 that the systematic development of modern respiratory protective equipment began.

A respirator is a device for rendering inhaled air respirable. In recent years the word has been applied especially to devices for protection against dust inhalation, but the broader use of the term is preferable. Brown (1)[1] has suggested the following classification of respirators:

I Supplied-air respirators
- A Self-contained type
  - 1 Oxygen breathing apparatus
- B Hose type
  - 1 Hose mask
  - 2 Air-line respirator
  - 3 Abrasive-blasting respirator

II Air-purifying respirators
- A Chemical-filter respirator
  - 1 Acid-gas, or type A
  - 2 Organic-vapor, or type B
  - 3 Ammonia, or type C
  - 4 Carbon monoxide, or type D
  - 5 Combinations of 1, 2, 3, and 4
- B Mechanical-filter respirator
  - 1 Dust, or type A
  - 2 Fume, or type B
  - 3 Mist, or type C
  - 4 Combinations of 1, 2, and 3
- C Chemical- and mechanical-filter respirator
  - 1 All combinations of A and B above (Group II)

GENERAL REQUIREMENTS

There are several important considerations applicable to all respiratory protective equipment: First, the device must not offer an annoying resistance either to inspiration or expiration; secondly, it must afford a definite degree of protection under well-defined conditions; thirdly, it must be reasonably comfortable, it must not interfere unduly with vision, and it must not be too heavy—all of these items being subject to certain latitude.

The amount of air breathed and the oxygen consumed by the average healthy 150-lb man is given in Table 1.

TABLE 1 AIR BREATHED AND OXYGEN CONSUMED

(After Henderson and Haggard)

	Oxygen consumption, liters per min	Air breathed, liters per min
Rest in bed, fasting	0.240	6
Sitting	0.300	7
Standing	0.360	8
Walking, 2 mph	0.650	14
Walking, 4 mph	1.200	26
Slow run	2.000	43
Maximum exertion	3 to 4	65–100

It was decided in the gas-mask studies carried out during the War that 85 liters per minute represented the maximum amount of air likely to pass through a mask at either inspiration or expiration. Of course no one but the exceptional person, such as a long-distance runner, breathes at 85 lpm for more than a few moments, but half that rate, or 42.5 lpm, is not unusual. Since one inspires approximately one-half the time and expires the other half, the actual minute volume breathed should be doubled,[2] hence the figure of 85 lpm; and it is this figure which is commonly used in measuring resistance. Measurement is made with the aid of simple set-up illustrated in Fig. 1 precisely as one measures pressure differences in air ducts or in chimneys. The muscles which raise and lower the chest in respiration are not strong and easily become tired if overworked. Any serious impediment to inspiration is fatiguing and causes a building up of excessive carbon dioxide in the blood, a desire to breathe rapidly, and a degree of discomfort which quickly may become so distressing as to

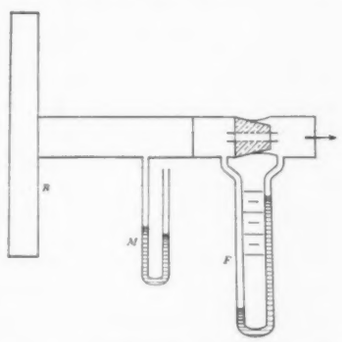

FIG. 1 ARRANGEMENT FOR TESTING THE RESISTANCE TO AIR FLOW OF VARIOUS FORMS OF RESPIRATORS

(R = respirator, M = water manometer, F = flow meter with capacity of 85 liters per minute.)

[1] Numbers in parentheses refer to similarly numbered items in the bibliography at the end of this paper.

Contributed by the Safety Committee and presented at a session on Occupational Diseases at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] Actually the respiratory cycle is usually irregular, but for mask testing it is permissible to consider it symmetrical and to ignore the pause at full inspiration or expiration.

FIG. 2 HALF-HOUR OXYGEN-BREATHING APPARATUS—APPROVED BY THE BUREAU OF MINES (2)
(Courtesy Mine Safety Appliances, Pittsburgh, Pa.)

cause the inexperienced wearer of a mask to take it off. It is not difficult to train oneself to breathe against rather high resistances but this training requires the incentive of extreme hazards or the discipline possible in war. It is not a practical peace-time expedient and should not be necessary. For gas masks the Bureau of Mines now allows an inspiratory resistance of 3.5 in. and 1.5 in. to expiration at 85 lpm. In dust respirators the Bureau's schedule permits maximum resistance of 2 in. to inspiration and 1 in. to expiration, all tests being made at the completion of filtering-efficiency tests and not simply when the device is new. These resistances should be lowered from time to time as general improvements in industrial respirators warrant more severe specifications, for it will be found that even 2-in. resistance at 85 lpm is unpleasant for long periods.

Oxygen-Breathing Apparatus. After a fire or explosion such as occurs in mines, rescue work must be quick, and the rescuers must enter atmospheres of unknown composition. Often an added difficulty is dense smoke through which the visibility is poor. Rarely is there any chance for the use of hose-type equipment. In spite of such obstacles there are numerous records of rescues made by men wearing self-contained apparatus for which the wearer carried his own oxygen supply.

A modern oxygen-breathing outfit is shown in Fig. 2. Oxygen is carried in a small steel bottle which leads through a special reducing valve to the breathing bag and then to the face piece. Since an average man engaged in fairly heavy exercise needs 2 to 3 liters of oxygen per minute, the exhaled air of the wearer of oxygen-breathing apparatus must be purified and re-used. Otherwise the man would be able to carry only a few minutes' oxygen supply.

The regenerating and purifying device consists essentially of a container or cartridge of a suitable carbon-dioxide absorber such as soda lime (Na_2OCaO). The oxygen consumed is then made up by the addition of oxygen from the breathing tank.

At altitudes in excess of about 15,000 ft experienced airplane pilots use oxygen-breathing equipment varying from a simple arrangement for giving the pilot an occasional breath of oxygen to complete equipment which must be worn continually. At sea-level pressures, there is no limit to the gas concentration against which an oxygen-breathing equipment protects, although it obviously cannot protect the wearer against gases, like hydrocyanic acid, which are absorbed through the skin.

Hose Mask. In Fig. 3 is shown a hose mask with the wearer carrying out a task for which the device is particularly suited. Here the air hose must be strong enough to be used as a life line in emergencies, must be impermeable to oils, gasoline, and water, and must not collapse under heavy weight. Air is supplied by a hand-operated blower.

As in the case of oxygen-breathing apparatus, there is no limit to the atmospheres in which hose masks give safe protection, saving possible harm through skin absorption. The hose must be of sufficient diameter to let the wearer breathe in case the operator of the pump should have to stop for a short interval. It is found that a safe minimum hose diameter is $^7/_8$ in. It is impracticable to pump air by hand through long lengths of hose and difficult to breathe through more than 150 ft should the air supply be cut off. Therefore, the device is definitely limited to use in places where the blower can be placed within 150 ft of the wearer.

The Bureau of Mines requires that the exhalation valve on the face piece shall not have a resistance at 85 lpm of more than 1.5 in. Because of the danger of the hand-driven blower's stopping occasionally, the inspiratory resistance through the blower, the hose, and face piece should not exceed 2.5 in.

It has been found safe for men to enter empty tank cars, shallow manholes, and the like with hose masks without blowers. The wearer then breathes through a gas-proof hose and is safe as long as the inspiratory resistance of the hose is low and the inlet of the hose remains in clean air. Such an arrangement does not dispense with the need of a strong hose which can serve as a life line in the event of some mishap to the wearer

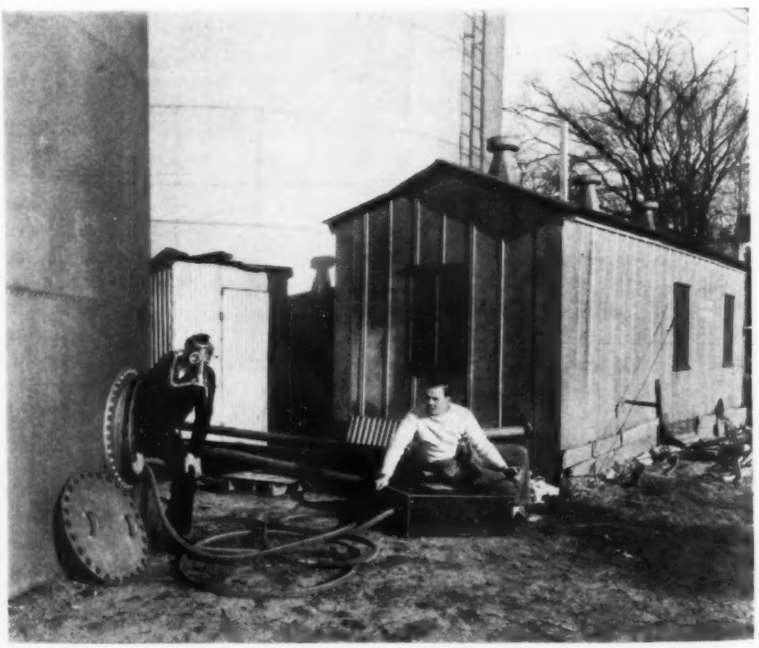

FIG. 3 HOSE-MASK EQUIPMENT—APPROVED BY BUREAU OF MINES (3)
(Courtesy Davis Emergency Equipment Company, Inc., New York, N. Y.)

of the mask, nor should it dispense with an observer outside the zone of danger.

Air-Line Respirators. The positive-pressure respirator, Fig. 4, worn in such jobs as paint spraying, is an outgrowth or simplification of the hose mask. It is adapted to all work in which there is no severe hazard to the wearer should he remove the device momentarily. That is, it should not be used in dangerous atmospheres to which the hose mask or the oxygen-breathing apparatus is especially suited. Air-line respirators are much less expensive than hose masks, the air line may be of small-bore compressed-air hose, and no life line is needed. If the air supply is cut off, the wearer simply removes his mask and moves out of the polluted air.

In general, air-line respirators can be worn for long periods, as they are light and there is little discomfort to the wearer. As yet there are no specifications for these respirators, but their effectiveness can be judged satisfactorily by requiring the wearer to spray an emulsion of black pigment in water, and after some 15 or 20 minutes' typical spraying work, comparing his nasal discharge and sputum with specimens taken before spraying.

Abrasive-Blasting Respirators. One of the severest dust hazards is abrasive blasting of sandy castings with sand as the abrasive cleaner. Of less danger is blasting with steel shot, but neither process should be permitted unless the blaster wears a respirator of the general type shown in Fig. 5. The device must protect the workman against flying particles and should be supplied with air at sufficient pressure and volume to insure a slight but constant positive pressure at the nose and mouth.

FIG. 4 AIR-LINE RESPIRATOR
(Courtesy Willson Products, Inc., Reading, Pa.)

Unfortunately, abrasive blasters are often the least intelligent workmen in the plant. It is not at all uncommon to see the blaster finish a job, open the doors of the blasting chamber, take off his helmet and then blow the loose material off the castings, thus making it certain that he will breathe dust he should avoid and that his helmet and his own head are well bathed in dust. Obviously, he will breath this dust when he puts on his helmet again.

FIG. 5 ABRASIVE-BLASTING RESPIRATOR
(Courtesy W. W. Sly Manufacturing Company, Cleveland, Ohio.)

Respirators suitable for this work can be made in various forms. The essential specification is that the wearer receives air substantially as clean as that from the compressed-air line. Tests demonstrating this fact should be made under practical blasting conditions—tests such as that suggested for air-line respirators are quick and will eliminate many poor abrasive-blasting respirators, but final acceptance of a blasting respirator should rest upon a practical demonstration in which the air within the device is sampled and compared with that from the air line.

It was suggested by Bloomfield and Greenburg (4) that air flows of at least 6 cfm per helmet were required but it is now recognized generally that less than 6 cfm often suffices. However, in estimating air flows to be supplied to blasting respirators at least 6 cfm per man should be allowed. No harm results from using too much air within the helmet while too little may result in negative pressures during inspiration. One can notice momentary pressure drops by the sensation on the ear drums, and the wearer should be taught to turn on enough air so that he can not notice this change even on taking a deep breath.

Air Purifiers. In most mines and in most dusty plants compressed air is available, but is apt to be wet and smell objectionably of oil. Also it may be unpleasantly cold when expanded directly into a respirator.

It is not difficult to clean, dry, and warm compressed air so that it is suitable for breathing. Various expedients can be adopted, one of which is shown in Fig. 6.

Plants having no compressed air would do well either to install compressors in which the intake air has no contact with oil or else to use a rotary compressor capable of delivering air at a pressure of 10 to 20 lb per sq in. Obviously, the air supplied should be free from harmful dusts. Accidents in which the intake of oil-lubricated compressors has been contaminated with the exhaust gas from gasoline-driven motors or in which some of the lubricating oil has been converted into carbon

monoxide are much more common than is generally supposed.

Chemical-Filter Respirators or Gas Masks. The Bureau of Mines has detailed specifications for the construction and performance of gas masks which protect against any gas or against any combination of gases. In Fig. 7 is shown a so-called "all-service mask" which protects against any combination of gases as well as against smokes and dusts.

In general the most important ingredient in gas-mask canisters is activated carbon, about 8–14 mesh in size. Carbon of high adsorptive capacity is now obtainable and is controlled by exacting specifications. It is effective against dilute concentrations of such organic gases and vapors as gasoline, and has an appreciable effect against organic acids such as formic or acetic. Furthermore, a mask approved against mercury vapor contains charcoal as the essential air purifier.

Of next importance is an alkaline absorbent such as soda lime, which reacts with acid gases such as carbon dioxide, sulphur dioxide, and hydrogen sulphide. Ammonia can be caught by silica gel (6) and by the special reagent, cupramite, which is activated carbon or pumice impregnated with copper sulphate (7). Carbon monoxide is not directly absorbed by any reagent but is converted by a special catalyst, hopcalite (8), into carbon dioxide and that in turn is caught in soda lime. One of the important difficulties in carbon-monoxide adsorption is dissipation of the heat generated when the carbon monoxide is oxidized to the dioxide. This heat loss is realized by passing the oxidized gas through a special radiator on top of the canister.

In general, gas masks will not protect against concentrations exceeding 2 to 3 per cent of the inspired air and of course they will not make up for oxygen deficiency. Their life lasts only as long as the ingredients of the canister retain their required efficiency. Some masks, such as that shown in Fig. 7, are obtainable with timing devices which are actuated by the wearer's respiration and thus show when the canister should be renewed.

FIG. 6 AIR-PURIFIER
(Courtesy E. D. Bullard Co., San Francisco, Calif.)

FIG. 7 ALL-SERVICE MASK—APPROVED BY BUREAU OF MINES (5)
(Courtesy Mine Safety Appliances Company, Pittsburgh, Pa.)

Chemical-Cartridge Respirators. There are many jobs in which some protection against gases is welcome but the lack of such protection does not involve a serious risk. In Fig. 8 is shown a cartridge-type respirator which is used for protection against low concentrations of such gases as gasoline and sulphur dioxide, and in certain paint-spray jobs.

Obviously, such a device is cheaper than an air-line respirator or gas mask and attracts purchasers accordingly. It is not a substitute for either of these devices and should never be used for protection against severe hazards. In its favor are its extreme simplicity and the readiness with which expended cartridges can be renewed.

Mechanical-Filter or Dust Respirators. These devices are intended to protect only against particulate matter and are not to be used against gases. As the result of the formulation by the Bureau of Mines of an approval schedule (9), dust respirators have been improved greatly and now are available in efficient forms with low resistance to breathing, Fig. 9.

Dust respirators, unlike the filters of commercial dust collectors, must be highly efficient at the outset—they cannot rely upon usage or dusting to plug the pores of the filter substance and thus improve the dust catching. It is not an easy matter to catch such substances as finely divided lead fume or fine quartz dust and still have a device through which the untrained wearer can breathe with reasonable comfort.

In general the filter materials now in use in the approved respirators are of wool felt or of specially impregnated paper (10) or various combinations of the two. Air velocities through the fresh filters are about 20 fpm compared to 2 to 6 fpm used in commercial filter cloths for dust collection. It is generally recognized in practical respirator manufacture that thin filter

FIG. 8 CHEMICAL-CARTRIDGE RESPIRATOR
(Courtesy Willson Products, Inc., Reading, Pa.)

substances plug rapidly. If they are used in respirators, provision for frequent changes of filters is necessary. Thick filters of wool felt; on the other hand, plug slowly but are too expensive to discard and are cleaned by compressed air or by shaking.

There is every reason to believe that better filtering materials will be made, and it is important to note that the Bureau of Mines' requirements permit the greatest latitude in the selection and manufacture of the filters. It is probable that the Bureau's resistance requirements, which are now more severe than those for gas masks, will be made still more severe in the future.

Nonapproved Dust Respirators. There are many dusty jobs for which less effective dust respirators are suited. The Bureau's stamp of approval has in the eyes of many an unwarranted legal significance which has yet to be upheld in court. Some firms, driven panicky by the present silicosis-dust racket, have even gone so far as to stock up with "approved" respirators so that they might be able to show they have on hand the best respirators made in case they find themselves defending a dust-compensation lawsuit.

There is not the slightest reason to use the best respirators against flour, cocoa, limestone, cement, and many other dusts. It is more to the workman's interest to give him a less elaborate device which may be less effective but which is also more comfortable, Fig. 10. Indeed, there are jobs with high quartz-dust exposure in which it would be much better to provide the men with nonapproved respirators which the men would wear than to supply approved devices which remain in the stock room or are worn only in the presence of superiors.

DISCUSSION

It can be said of all the mechanical-filter-type or dust respirators that they are a poor substitute for dust control. Ultimately it is not an economy to supply workmen with air-line respirators or with dust respirators instead of installing the proper dust-control equipment. Further, the time is not far off when the courts and compensation boards will make short shrift of the employer who lets his men work in dense clouds of dust, regardless of what the dust is.

In general the employer would do well to try some of the dusty jobs himself, wear the men's respirators, and thus decide whether or not it would be better to install dust control instead of respirators. However, dust respirators are centuries old; they have a legitimate place in industry, and are an important aid in the prevention of dust inhalation, but they are not a substitute for dust prevention and never should be used as such.

This sort of criticism does not apply with the same force to the other types of respirators. Oxygen-breathing apparatus, gas masks, and hose masks are all used in emergencies, usually resulting from accidents. Hose masks may be used routinely, but they are sold in single units while dust respirators are apt to be sold and used by the gross. Also, air-line respirators and abrasive-blasting respirators are often applicable to situations

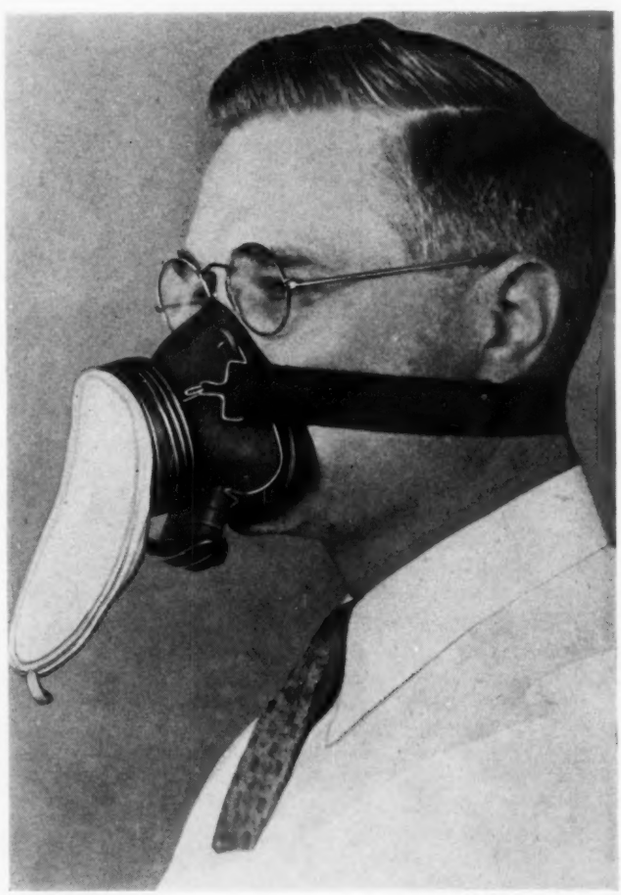

FIG. 9 DUST RESPIRATOR FOR USE AGAINST LEAD AND SILICA DUST (8)—APPROVED BY THE BUREAU OF MINES
(Courtesy Willson Products, Inc., Reading, Pa.)

in which the employer conscientiously has taken *all reasonable precautions* to prevent dustiness.

At the present writing there are United States Bureau of Mines' specifications for approval of all of these devices except the air-line and abrasive-blasting respirators. The American Standards Association and the Bureau of Mines are now preparing specifications for this complete list. The United States Navy and Army have further specifications for various types of equipment. The purpose of all such specifications—certainly those of the Bureau of Mines—is to insure a product adequate for the protection needed, without putting undue restraint upon the respirator manufacturer's ingenuity.

Care of Respirators. Because of their special construction and the composition of the chemical ingredients of various of these devices, their deterioration is fairly rapid. Companies like the utilities using them in considerable quantity maintain a regular repair service which sees that all equipment is inspected regularly and all is in first-class condition before being reissued. Generally, the firms which sell respirators furnish reliable directions for storing, cleaning, sterilizing, and repairing all equipment.

In conclusion the author wishes to make clear that equipment of the type described in this paper ages rapidly—today's new models will appear on tomorrow's museum shelves. The Bureau of Mines' approval, desirable as it is, does not tell the purchaser which is the best equipment but merely insures him that the approved article is what might be called "first-grade." Testing these devices is a service offered by the Bureau for the help of industry and it is to industry's advantage to patronize this service.

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5 "Procedure for Testing Gas Masks for Permissibility," U. S. Bureau of Mines, Schedule 14D of May 9, 1935.

6 U. S. Patent 1,586,327.

7 U. S. Patent 1,559,980.

8 "The Removal of Carbon Monoxide From Air," by A. B. Lamb, W. C. Bray, and J. C. W. Frazes, *Journal, Industrial and Engineering Chemistry*, vol. 12, 1920, p. 213. See also U. S. Pat. 1,345,323.

9 "Procedure for Testing Filter-Type Dust, Fume, and Mist Respirators for Permissibility," U. S. Bureau of Mines, Schedule 21 of August 20, 1934.

10 U. S. Patents 1,798,164; 1,814,190; 1,818,155.

FIG. 10 DUST RESPIRATOR FOR USE AGAINST DUSTS SUCH AS ZINC OXIDE, COCOA, FLOUR, AND SODA ASH
(Courtesy Willson Products, Inc., Reading, Pa.)

THE BROOKINGS REPORTS

By DONALD S. TUCKER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A CAT may look at a king, and I have been asked to summarize and criticize the four volumes recently published by the Brookings Institution.[1] These volumes have been reviewed in previous issues. Only their monumental importance warrants further comment; and only a monumental conceit would warrant a criticism of their contents by some one who has not, like these authors, spent more than $150,000 in collecting, checking, and comparing the information presented there. Most economists are content, therefore, to accept without question statistical results presented in these volumes because of the high reputation of these authors and because of the internal evidence in these volumes that this work also has been performed scrupulously. Nevertheless, certain comments seem appropriate. Certain inferences clearly implicit in their findings may be stated explicitly even though such statement is possible only by subjecting the conclusions of these authors to some oversimplification. It would not be possible otherwise to condense 1200 meaty pages into a two-page summary. Yet some such process of generalization seems warranted. For most readers, other than professional economists, these conclusions or inferences form the very heart of the report.

(1) *Productive plant and technique are sufficient to provide greater income per capita and a more abundant life for all.*

Our productive power is not unlimited. Plant, mechanical power, human skill, and human capacity for toil are all definitely limited; but even in the most prosperous periods some plant stands idle and some labor remains unemployed. Defects exist, therefore, in our economic organization. Utilization of our facilities up to the degree represented by the possibilities now practical would increase the national income by about 18 per cent over that realized in years of full prosperity (e.g., 1925–1929). This conclusion is supported by the fact that during the Great War we actually increased our output by nearly 15 per cent. Adjustment and planning more carefully than was possible at that time would make possible an increase in output slightly larger than that then attained.

(2) *The possible increase in human comfort is very large.*

When stated as a percentage the increased income possible does not sound so great; but a 19 per cent increase in output would have added 15 billion dollars a year to the national income. Such an increase would have added on the average $545 to the income of every family of two or more persons, or would have given an additional $125 per year to every man, woman and child in the United States. This increase in income would have resulted in a disproportionate decrease in misery. Involuntary unemployment is one of the greatest causes of poverty. More perfect employment would eliminate this source of distress except for the unemployables. It is of course impossible to predict precisely how the benefits of increased production would have been distributed; but there can be no doubt that it would have operated to reduce greatly poverty among those able and willing to work.

(3) *Additional output and additional goods were badly needed even in our most prosperous years* (1925–1929).

Business output is restricted by the lack of a profitable market. This lack of demand is not due to a lack in the need for goods. It is due rather to lack of the income with which to buy goods. A "liberal diet" would have cost $950 per family at the prices of 1929. But no family spends for food alone and increasing income is spent for clothing, housing, etc., as well as food. To give families with incomes less than $5000 a liberal diet, it would have been necessary to increase the expenditure on food by about 40 per cent, the expenditures on homes and home maintenance by nearly 100 per cent and the expenditure on attire and adornment by more than 100 per cent. Given our habits of expenditure, an increased output of consumption goods amounting to more than 70 per cent would have been necessary. Satisfaction of all wants is therefore still a far distant goal. The problem now is rather to increase income sufficiently to permit purchase of the goods already desired.

(4) *Redistribution of existing income from production would not satisfy existing wants.*

Eighty per cent of the income from production goes to pay for human services; only about 20 per cent of the income from production goes to pay the owners of capital goods. Property owners receive more than 20 per cent of the total national income only because many consumers do not own the consumption goods (e.g., homes) which they use. Redistribution of the income from production would not eliminate income from property and might curtail production. To increase the total income from production is more important than to redistribute the income already arising.

(5) *Shortening the hours of labor reduces output and income.*

It is of course true that a society whose income is increasing may take some portion of that increase in the form of greater leisure; but we have not yet reached a point where hours may be reduced without reducing income. To realize the 19 per cent increase in national income which was assumed as possible, hours would need to remain unchanged and the labor force redistributed and readjusted with the greatest care. To realize this increase in the income from production 1,000,000 additional laborers would be needed in some industries and about that number could be released from part-time employment in others. The condition necessary for the maximum national

[1] "America's Capacity to Produce," by Edwin G. Nourse and Associates. Washington, The Brookings Institution, 1934. Cloth, $5^1/_4 \times 8^1/_4$ in., 608 pp., $3.50. MECHANICAL ENGINEERING, August, 1935, pp. 507–508.

"America's Capacity to Consume," by Maurice Leven, Harold G. Moulton, and Clark Warburton. Washington, The Brookings Institution, 1934. Cloth, $5^1/_4 \times 8^1/_4$ in., 272 pp., $3. MECHANICAL ENGINEERING, August, 1935, pp. 507–508.

"The Formation of Capital," by Harold G. Moulton. Washington, The Brookings Institution, 1935. Cloth, $5^1/_4 \times 8^1/_4$ in., 207 pp., $2.50. MECHANICAL ENGINEERING, August, 1935, pp. 507–508.

"Income and Economic Progress," by Harold G. Moulton. Washington, The Brookings Institution, 1935. Cloth, $5^1/_4 \times 8$ in., 192 pp., $2. MECHANICAL ENGINEERING, February, 1936, pp. 130–131.

Twelfth of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

output and income is substantial full-time employment of all workers, those now employed part-time as well as those now idle.

(6) *Saving without investment is the immediate cause of much waste.*

Output determines the income from production. The values added by production determine the amount available for profits and other incomes. The amount of value added (and, consequently, of income) depends, however, upon the demand for goods, and this in turn depends on the amount of previous income and its utilization. Saving reduces consumption demand (and the income from the production of consumption goods). Investment increases the demand for production goods (and the income received from the creation of production goods). If saving and investment proceeded simultaneously, there would be no loss because of saving. If savings are held without investment, the national income is reduced. In such cases prices must be decreased or the volume of production curtailed.

(7) *Monopoly is a basic cause of waste.*

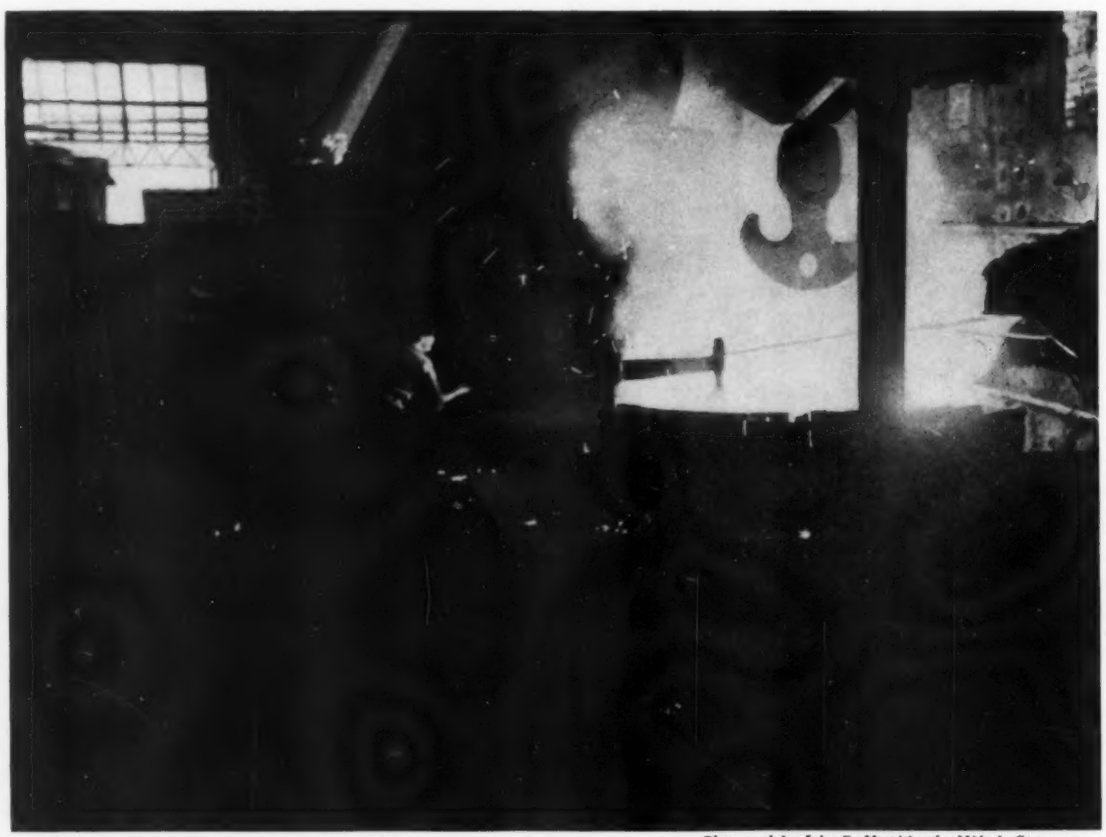
Monopoly reduces the national income in two ways: (*a*) By charging prices higher than ordinary competitive prices, it reduces the capacity of consumers to buy other goods and services in the volume which would otherwise be possible. Monopoly in some fields may therefore produce unemployment and idle plants in other more competitive fields. (*b*) Monopoly restricts investment in the monopolized field. An extreme example occurs in the electric light and power industry. So closely had capacity been limited to actual consumption in this industry that it is probably fortunate that depression public works include some electric plants. Restriction of investment causes savings to remain idle, production to be restricted, and the national income to be reduced.

(8) *Trade associations are now the most important form of industrial monopoly.*

Monopoly in this country has assumed chiefly one of three forms: Outright combination, the pool or cartel, and the trade association. Legal restrictions in recent years have prevented the formation of new monopolies by the first two methods. Trade associations, because of the intangibility of their control, have, however, largely escaped the law's prohibitions. Monopolistic practices reduce the demand for goods no matter how informal the source of monopolistic control. Competition among rival manufacturers for the opportunity to sell goods at rigid or monopolized prices does not bring to consumers the essential benefit of reduced prices.

(9) *In the growth of trade associations and of monopolistic practices of various kinds lies a basic cause of this depression.*

Most economists would add that the continuance of monopolistic controls was an important cause of the long continuance and great severity of this depression. It is not sufficient merely to abandon the NRA. Vigorous enforcement of the Sherman Act is also needed. The Brookings report stops, however, with the year 1929. Volumes 3 and 4 of that report give an analysis of the way in which the growth of monopolistic practices made depression inevitable even if other forces had not contributed to this result.



Photograph by John P. Mudd for the Midvale Company

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

APPLIED MECHANICS

Combined Alternating Stresses

IN this paper the authors for the first time have investigated the behavior of materials under a combination of alternating stresses, in this case cyclic torsion together with cyclic bending.

The particular importance of this combination arises from the fact that it is the combination encountered in engine crankshafts. The field of investigation has been restricted to the condition in which the mean value of both the cyclic stresses was zero. The investigation therefore covered a study of the behavior of metals when subjected to a bending stress varying from $+f$ to $-f$ in combination with the torsional stress varying from $+q$ to $-q$, the zero value of the one range agreeing simultaneously with the zero value of the other. The research is not completed, and the paper presents the results obtained with only three materials, each of which has been subjected to seven different combinations of bending and torsional stress ranging from all-bending and no torsional stress to all-torsional and no bending stress. The materials on which the tests were made are 0.1 per cent carbon steel in the normalized condition, $3^1/_2$ per cent nickel-chromium steel in the hardened and tempered condition, and Silal iron in the "as-cast" condition.

The machine on which the tests were conducted is illustrated and described in the original article. Some of these machines are already used in research by laboratories in England.

The results of the research on the three metals are summarized in a table in the original article, and the authors analyze one line referring to the mild-steel materials with the specimen set at 15 deg relative to the loading arm. This highly interesting part of the article cannot be abstracted because of lack of space.

The important point to discover from the figures given in the table is the answer to the question, What factor or what combination of factors causes a metal to fail when it is subjected to combined bending and torsional cyclical stresses? Did the mild-steel specimens at 15 deg fail because the loadings to which they were subjected induced a maximum tension greater than 17.3 tons, or because they had to bear a maximum compression in excess of 17.3 tons or because the shear stress which they were called upon to withstand covered a greater range than ±8.8 tons?

For guidance in the analysis of their results the authors turned to the various theories which have been propounded to explain the cause of failure of metals when subjected to a combination of *static* stresses, although there is no a priori reason why static conditions should have the same criterion of failure as kinetic conditions.

These theories are: The Guest law (failure occurs by virtue of the fact that the maximum shear induced by the combined loading exceeds the ultimate shear strength of the metal); maximum-stress theory (failure occurs by virtue of the value of the maximum principal stress); and St. Venant's theory (failure is determined by the maximum principal strain exceeding the limit value); the Beltrami theory (failure occurs when the total elastic strain energy in unit volume of the material exceeds a certain limit); and the von Mises-Hencky theory (failure occurs when the energy corresponding to the shear strain expressing the energy due to the tensile and compression strains exceeds a limiting value).

It will be seen that in the case of the mild steel, Fig. 1, the experimental points fall almost exactly as they should if constant-shear-energy theory of von Mises and Hencky were true. For the nickel-chromium steel, Fig. 2, however, the experimental points are in closest agreement with Beltrami's constant-total-energy theory. For the "Silal" cast iron the experimental points conform reasonably closely to the maximum-principal-stress theory.

For the time being and until the research is carried farther the authors do not consider it desirable to discuss the difference in behavior thus revealed by the three metals. The fact that no one of the five theories appears to be generally applicable does not invalidate the possibility that some rational theory may be found to cover the results. Meanwhile, noting the fact that the results obtained from the two steels Figs. 3 and 4 fall on elliptical curves, the authors have devised an empirical formula which closely expresses them, although no definite physical meaning can at present be assigned to it. This formula is

$$f^2/f_1^2 + q^2/q_1^2 = 1$$

where $\pm f_1$ and $\pm q_1$ are the fatigue ranges

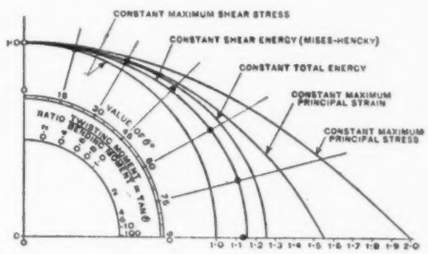

CONSTANT MAXIMUM SHEAR STRESS
CONSTANT SHEAR ENERGY (MISES-HENCKY)
CONSTANT TOTAL ENERGY
CONSTANT MAXIMUM PRINCIPAL STRAIN
CONSTANT MAXIMUM PRINCIPAL STRESS
VALUE OF θ°
RATIO TWISTING MOMENT / BENDING MOMENT = TAN θ

FIG. 1 0.1 PER CENT CARBON STEEL UNDER ALTERNATING STRESSES

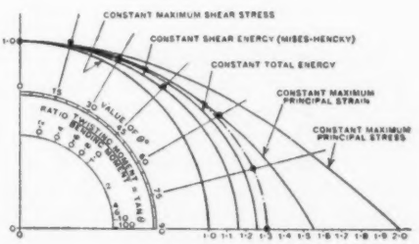

CONSTANT MAXIMUM SHEAR STRESS
CONSTANT SHEAR ENERGY (MISES-HENCKY)
CONSTANT TOTAL ENERGY
CONSTANT MAXIMUM PRINCIPAL STRAIN
CONSTANT MAXIMUM PRINCIPAL STRESS
VALUE OF θ°
RATIO TWISTING MOMENT / BENDING MOMENT = TAN θ

FIG. 2 $3^1/_2$ PER CENT NICKEL CHROMIUM STEEL UNDER ALTERNATING STRESSES

of the metal as determined by plane bending and pure torsion tests separately and $\pm f$ and $\pm q$ are the ranges of direct and shear stress due to the bending and torsional portions of the loading at the fatigue limit of the metal when subjected to combined cyclical stress. In other words, given the separate fatigue limits f_1 and q_1 of the metal, we may subject it with safety to combined cyclical stresses producing a range f of direct, tensile and compressive stress, provided the simultaneously existing torsional stress does not exceed a value of $q = q_1 \sqrt{(1 - f^2/f_1^2)}$. How closely this expression reproduces the experimental results may be judged from Fig. 6 in the original article. (H. J. Gough and H. V. Pollard paper before the Institution of Mechanical Engineers, abstracted through *The Engineer*, vol.

160, no. 4165, Nov. 8, 1935, pp. 484–486, 6 figs. Compare editorial in the same issue, p. 483)

ENGINEERING MATERIALS

High-Impact Bakelite Materials

THE incorporation of primary resinoid with woodflour, as in the production of the standard woodflour-filled materials, provides good molding quality and improved impact resistance in the molded product. Incorporation of the primary resinoid with paper or fabric, as in the production of the so-called laminated materials, gives a product that may be hot-pressed into plates or other simple forms only, but which nevertheless has greatly increased resistance to impact.

The impact molding materials bridge the gap between these two extremes. There is a whole series of these materials, providing impact strengths of 5 to 6, 9 to 11, 11 to 13, 18 to 20, and 25 to 30 ft-lb for an inch square, respectively. The first in the series gives molded products having impact strengths about three times that of standard woodflour-filled molded products, and with but little sacrifice of molding or pre-forming qualities. The last in the series gives molded products having ten or more times the impact strength of the standard woodflour-filled materials, but must be molded under a pressure of about 5000 lb per sq in. and can be pre-formed in a hand press only, instead of an ordinary tableting machine.

A table in the original article gives the properties of bakelite-molded high-impact materials. (*Electrical News and Engineering*, vol. 44, no. 22, Nov. 15, 1935, pp. 23–25 and 39, illustrated)

FOUNDRY

Continuous Pouring of Ford Cylinder Blocks

THE iron from one of the two blast furnaces is delivered to a mixer containing a definite quantity of cast iron from a battery of cupolas, the molten pig iron being standard foundry iron. The composition of the metal for cylinder blocks is given in the original article. It is regular gray-iron composition plus 0.50 to 0.75 per cent copper, it being claimed that this addition produces higher anti-knock or shock-resistant properties, as well as increased fluidity and wear resistance. The iron is then finished in an electric and air furnace.

In front of the electric furnace is a 25-ton specially designed air furnace fired with pulverized coal. Into this, at intervals of every 20 to 30 min, the hot metal flows by gravity from the electric furnace, not less than 40 tons an hour.

Little alteration in composition of the metal takes place in either the electric or the air furnace, though there is some refining action in the electric. The air furnace is largely a heating reservoir for the pouring operations which follow. This is the major feature of the continuous process.

From the time the superheated metal leaves the electric furnace until it reaches the molds, there is no interruption in its flow. Ford engineers have perfected a novel apparatus which receives the metal as it flows in a trough from the air furnace—a movable pouring truck or ladle—which is so synchronized in its longitudinal and rotary motion that it receives metal continuously and discharges the metal intermittently to the molds as they travel along beside the ladle truck (or the trough) on the mold conveyer reel.

There are two such streams of hot metal, one from each end of the air furnace, delivered by the two pouring trucks to two processions of molds. The method has been in successful operation since early in August. The advantages claimed for it are stated in the original article. (Edwin F. Cone in *Metals and Alloys*, vol. 6, no. 11, November, 1935, pp. 299–302, illustrated)

FUELS AND FIRING

Wood Fuel Burning Tests

THE tests were conducted on hardwood, average maple firewood, soft wood, soft-pine slabs, and edgings. The results of the tests indicated that air-dried hardwood when charged on a perforated plate was more efficiently burned than with other arrangements of fuel and grate, with the exception of American anthracite. From the economic side this hardwood differed little from the air-dried softwood when burned on a perforated plate. The total refuse recovered in percentage of fuel fired is not worth considering.

Results of tests made on green hardwood which had been seasoned for three months show that its efficiency is not very low, but lower than that of air-dried hardwood. On soft wood three tests were conducted, two on the air-dried fuel seasoned for two years and one on the same fuel that had been seasoned for five weeks only.

Of the two tests on the air-dried wood one was made on the coal grate and the other on a perforated plate. It was found that the latter combination of fuel and grate was the most economic arrangement of all of this series of wood-burning tests. On the other hand, the thermal efficiency for this test was low in comparison with those found in the tests on air-dried hardwood, but higher than that obtained with the other arrangements of the soft-wood fuel and the grate.

Generally, wood fuel as tested here cannot be called a substitute for American anthracite except under special circumstances, but is almost the equal of air-dried machine peat when considered from an economic standpoint. The addition of a perforated plate materially improved the fuel consumption. (E. S. Malloch and C. E. Baltzer, Canada Department of Mines, Division of Fuels and Fuel Testing, No. 761, 1935, 4 figs, and 2 sheets of illustrations)

Resistance to Grinding of Coals

RELATIVE resistance to grinding of coal can be expressed by empirical terms. The ratio of the experimental value to the standard value has no units and the difficulty is to find a coal which would be universally accepted as a standard. A more fundamental problem is that determining an absolute value of resistance to grinding which could be used to assess the efficiency of a pulverizer. For this purpose resistance to grinding must be expressed in the fundamental units of mass, time, and length, and since the object of a pulverizing process is to expose new surface of material, the resistance to grinding is expressed most conveniently by the number of foot-pounds of energy required to produce one square foot of new surface. These units for surface energy are the same as the units that are used for surface tension.

The methods used for the determination of specific surface may be divided into two groups, chemical and physical. These two groups yield widely different results, since the chemical methods include the surface of interstitial fissures that are known to exist. The conception of specific surface that is maintained throughout this paper is that of the external-surface area of nonporous particles of irregular shape.

The details of the experimental methods are given in the original, in particular the subject of attrition between metal surfaces is treated. The so-called compression test was devised to disintegrate the coal in such a manner that

no appreciable proportion of the energy was lost in friction between particles or in other ways.

A cube of coal was compressed in an ordinary testing machine and the compressive strain measured as the load was increased. When the curve relating these two variables is plotted, the area below it gives the work done on the cube up to the instant of fracture. The work done or energy per cubic inch at fracture is defined as the limiting strain energy. Tests were made with the direction of compression perpendicular and parallel, respectively, to the bedding planes.

An interesting feature of the test is the shape of the particles produced. When the direction of compression is parallel to the bedding planes the particles are much flatter than when the compression is perpendicular to the bedding planes. This difference is still measurable on particles of 18-mesh size.

It is believed that the following holds good:

(1) Compressive strength and strain energy up to fracture are greater when the compression is perpendicular to the bedding planes. Exceptions occur when there are fissures perpendicular to the bedding planes, as with the anthracite, Great Mountain seam, and the Welsh team coal. In these cases the fissures exert the predominating influence. The anthracite, Red Vein seam, was so fissured and contorted in structure that it was impossible to determine the direction of the bedding planes.

The surface energy in foot-pounds per square foot is greater when compression is perpendicular to the bedding planes. Coals with fissures perpendicular to the bedding planes form exceptions to this rule.

The next investigation was on the effect of a sudden blow applied to a block of coal by means of the falling of a weight.

The crushing roll test was also tried. This has the same general tendency as the impact tests, but the curves plotted from it extend over a greater range of the energy scale.

The scratch-hardness test and abrasion test are discussed in detail. The following are among the conclusions deduced from the tests. The compression test determines the minimum energy required to fracture the specimen, which may be defined as the limiting strain energy. The amount of new surface produced cannot be controlled or altered, but depends solely on the characteristics of the material.

The attrition-test apparatus described has a low efficiency compared with the standard of the compression test. The attrition test does, however, place the coals in approximately the same order of resistance to grinding as they are placed by the more efficient tests.

Hardness can be measured by the scratch test and by the resistance to abrasion. These tests place the majority of the brittle materials in the same order as they are placed by the other tests referred to, but exceptionally tough materials, such as cannel and carbonaceous shale, have a resistance to abrasion which is out of all proportion to the comparatively low scratch - hardness values.

Throughout this paper the energy required to produce unit area of surface increase has been taken as the criterion of the crushing and grinding characteristics of a material, and this function must be used in any scientific investigation of the problem.

It is to be recognized, however, that the accurate elimination of specific surface is a complicated and laborious process, and that routine tests for determining relative resistance to grinding can only be based on a more simple test involving grinding to a standard fineness, defined by the percentage passing a specified sieve.

Such a test would be quite admissible if the energy required to produce the standard fineness were also measured, and if it had been ascertained that the mill had a constant efficiency (by comparison with the standard of the compression test) over the range of materials and energy inputs to be covered. (Harold Heywood, *The Colliery Guardian*, vol. 151, nos. 3907 and 3908, Nov. 15 and 22, pp. 898–900 and 941–942 for the original paper and pp. 942–944 for discussion, 7 figs.)

INTERNAL-COMBUSTION ENGINEERING

Compression Losses in Smaller Two-Stroke-Cycle Diesel Engines

DURING starting there occur in Diesel engines losses of compression not due to the cooling but to lack of tightness of the pistons. This means that the compression ratios must be smaller as the size of the unit increases, as otherwise the motor will not start without outside assistance.

In the present investigation an attempt is made to lay the foundations for the calculation of the necessary ratios of compressions in two-stroke-cycle engines, this being done with a comprehension of losses that actually occur. The processes are also considered which affect the closure of the ports. The investigation is limited to motors with jet injection, as in the fore-chamber type of machines starting without auxiliary ignition is impossible.

The author starts by considering the processes which take place when the ports are closed by the piston. He finds, among other things, an expression for the case when the port has been closed by the edge of the piston. The expression which he obtains is only a rather coarse approximation, sufficient, however, for practical purposes in view of the small influences of the rise in pressure during the process. He next considers the loss of charge from the closure of the port by the edge of the piston up to the time when the first piston ring slides over. This is followed by an extensive investigation of cooling losses during the compression.

The losses of gas during the compression is due to the fact that as soon as a complete closure of the port by the edge of the piston has been accomplished, a flow of gas takes place along the piston wall, like the flow through a labyrinth. Because of the piston clearances between any two rings, spaces are created, which, together with the differences between the inner diameter of the rings and the diameter of the corresponding ring space, form the chamber of this labyrinth. The narrow slots between the piston rings and the surfaces which hold them, as well as those between the rings and the cylinder wall, produce, together with the ring closures, the various places where throttling takes place.

The calculation of the masses of gas flowing through this labyrinth presupposes the knowledge of the law of efflux controlling such narrow slots. No test data are available on this subject. Stodola only (6th German edition, p. 153) published a short series of tests on the subject.

The present author investigates the subject mathematically and sets up the necessary equations. He then proceeds to the description of the tests which he made.

The article is of a mathematical character and is not suitable for abstracting. The main conclusion to which the author comes is that the compression ratio is a function of the size of the unit and its speed. (J. Zeman, communication from the Machine Laboratory of the Technical High School in Vienna, abstracted through *Forschung auf dem Gebiete des Ingenieurwesens*, Series B, vol. 6, no. 3, May-June, 1935, pp. 129–138, 7 figs.)

MACHINE PARTS

Change-Speed Gearing

GENERAL discussion of the problem with special reference to the Fawcett fluid clutch gear and the Piercey variable-ratio gear. Only the part dealing with the latter is here abstracted.

In the past friction gearing was not used to any great extent for power up to 50 hp. It is claimed that with the Piercey gear much greater powers can be

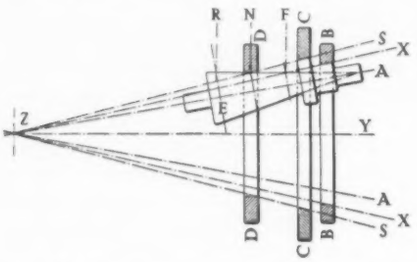


FIG. 3 PIERCEY SPEED-CHANGE GEAR IN SECTION

transmitted. These gears give an all-around efficiency of approximately 96 per cent, notwithstanding an impurity of rolling contact of 7 deg.

The principle of the Piercey gear is shown diagrammatically in Fig. 3 and in cross section in Fig. 4. This design gives a speed-range from zero to 1:1 in either direction of rotation while continuously under load, by the simple movement of the driven ring from *A* to *E*.

A necessary safeguard for this type of gear is incorporated to limit the torque increase, for although it is possible to vary the speed to any degree, it is impossible to provide for the consequent increase of torque, and a safety limiting device is a necessity for all variable-speed gears passing through a neutral position. In this gear an adjustable friction brake is used to hold the reaction ring stationary up to a predetermined loading, any overloading causing it to slip. The canceling rotating motions are shown in the diagram, Fig. 3.

The satellite rollers *E* are mounted in a cage free to rotate around center *ZY*, having their individual rotation upon a conical formation centered at *Z*. The driving ring *B* contacts with the rollers at *X* forming a cone of motion *XZX* rotating at the driving speed. The stationary ring *C* contacts with the rollers at *S* forming a stationary cone *SZS*. We therefore have three cones of different motions with a common peak at *Z*, one rotating in excess of the driving speed, one rotating at the driving speed and a third which is stationary, all with pure motions and pure rolling contacts. The satellite rollers have a reversed cone integral with the driving and stationary contacting portions, having its conical angle equal to the angle of cone *AZA*, thus giving an outer rolling surface parallel to the center line *ZY*, which surface is crossed by the cone *XZX* and *SZS*, one of which is rotating at driving speed and one stationary. Therefore, at the position *F* the rotational speed imparted to the ring *D* will be that of the driving ring *B*. At the position *N* no rotational motion will be imparted to the ring *D*, the forward rotation of the satellite caging being canceled by the opposite rotation of the satellite rollers themselves. At the position *R* a reverse rotation is imparted to the ring *D* owing to the opposite rotation of the satellite rollers becoming greater (due to increased diameter) than the forward rotation of the satellite caging. The lateral movement of the ring *D* thus gives any speed of rotation in either direction dependent upon its position.

Another design of this type of gearing for small loads for use as a counter shaft with belt drive is shown in the original article. It is said that this type of gearing generally appears to be suitable for machine tools where headstocks have as many as 16 changes of gear speeds and a similar number on their gear boxes. (C. G. Garrard, *Power and Works Engineer*, vol. 30, no. 355, October, 1935, pp. 393–396, 9 figs.)

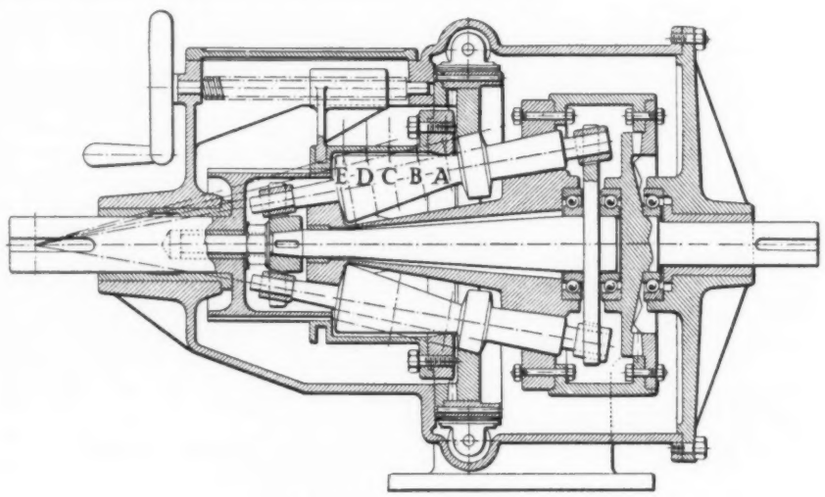


FIG. 4 PRINCIPLE OF PIERCEY GEAR

Recent Developments in Light Alloy Pistons

DEFLEURY has claimed, and his opinion has been endorsed by the French Academy of Sciences, that, provided metal of suitable mechanical strength is under discussion, the most advantageous material for use in making piston is obtained when the maximum is given by the ratio of the thermal conductivity to the product of the density and the coefficient of linear expansion. This explains why substantial percentages of silicon are added to aluminum in the manufacture of pistons though there are material difficulties in the manufacture of silicon aluminum alloy pistons both in the foundry and in the machine shop. These difficulties, however, have been overcome.

Exception has been taken to these alloys in the "as cast" condition. Although by suitable heat-treatment the Brinell hardness of a Y-alloy and similar alloys can be materially improved, the author shows that such improvement in physical properties brought about by heat-treatment is not permanent under the working conditions of a piston and that it is difficult to see what practical bearing the Brinell hardness has on the actual performance of the piston. He points out that millions of pistons have been in use made from the eutectic aluminum-silicon alloy with a Brinell hardness of less than 60, and have given excellent service.

In the author's opinion not enough attention has been paid in the past to the microstructure of the material from which the piston is made. He also points out that the use of the various modifications of the simple binary aluminum-silicon series for piston construction is increasing rapidly all over the world.

In the discussion which followed a question was raised as to what silicon alloy can be hardened by heat-treatment to 140 Brinell. The author replied that the element he would add to bring about

heat-treatment of the 35 per cent silicon-aluminum alloy with 0.5 per cent titanium, would be a small percentage of magnesium. Several questions as to the detail practice of machining and heat-treatment have been also covered in the discussion. (H. J. Mabrey, Institution of Production Engineers, Coventry Section, published in *The Journal of the Institution of Production Engineers*, vol. 14, no. 9, September, 1935, original article pp. 495–501, 2 figs., and discussion, pp. 502–506)

MACHINE-SHOP PRACTICE

Temporary Dies

THIS is a description of the plant set up by Dayton A. Rogers. The plant started some 15 years ago when the owner, then on the faculty of the University of Minnesota, wanted to produce a few hundred parts for an experimental domestic toaster. The success of this job led him to develop it into a commercial unit. As to the work itself there is no hard and fast method employed, this being altered to suit conditions, such, for example, as the thickness of the material to be punched. To date $^3/_8$-in. steel of various grades has been blanked in sizes up to 24 × 24 in. Some of these dies are now made for a life of 5000 pieces. (*The American Machinist*, vol. 79, no. 25, Dec. 4, 1935, pp. 880–881, 5 figs.)

MACHINE TOOLS

Machine-Tool Developments in 1935

THIS is a brief abstract of a survey of British and American machine-tool practice. Improving trade conditions have had a very marked reaction on the machine-tool industry. Many new engineering concerns have been inaugurated, existing concerns have expanded in a great many cases, and there has been a general tendency to replace obsolescent tools by those more suitable for present-day conditions. Consequently, not only has the machine-tool trade been fully occupied, but frequently the manufacturer has been faced with the embarrassment of being unable to increase production sufficiently to preserve the balance between supply and demand.

Of the features in design, perhaps the foremost is the increasing number of machines produced, adapted particularly to withstand the conditions demanded by cemented-carbide tools. Hydraulic operation is much in evidence, and definite efforts have been made to facilitate the control of machine tools. Certain progress has been made in the latter direction by the methodical centralization of controls, but the most striking development is the incorporation of electrical controlling systems, the advantages of which appear to have been explored more extensively on the Continent than elsewhere. A notable development in the design of spot-welding machines is the incorporation of the thyratron, and similar valve controls, with a consequent elimination of errors which were unavoidable previously, and with increased production.

The facilities offered for handling work in machines of reduced height has been appreciated to a fuller extent than was the case formerly, and in many instances the design has been modified accordingly. Other developments of note include the hydraulic control of sliding gears on drilling machines, and the Heynau gear, whereby stepless speed changing can be effected. The Heynau gear has been adopted on a number of machines.

Developments in centerless grinding practice have enabled the system to be adapted to the grinding of thin-walled sleeves, up to 3 or 4 in. in diameter, internally, and externally to the grinding of outside diameters, using a broad-face 14-in. wheel (Lidköping). At the other extreme, small rollers for needle bearings are centerless ground on machines incorporating hopper feed.

Pinion-type gear cutters have been developed (The Fellows Gear Shaper Co.) whereby roughing and finishing sections are provided on a single cutter. A face-mill type finishing cutter for spiral-bevel and hypoid ring gears (The Gleason Works) employs inserted blades of progressive depth and finishes one tooth per revolution of the cutter. Double-gap cutters (Fellows) have been developed on which the upper and lower sections are separated by a washer, admitting of cutting on both strokes of the ram.

Color control (Kendall & Gent) has come into prominence; a single movement control has been developed (A. A. Jones & Shipman), and applied to a duplex boring machine; and a vertical automatic drilling, boring, and reaming machine (Kitchen & Wade) has been designed to incorporate cam unit heads. In addition, mention may be made of electrical gearless drive, one application of which was to a plain milling machine (Alfred Herbert); the use of fans to prevent overheating and the ingress of chips, and the incorporation of an electromagnetic tool lift on a planing machine (Craven Bros.). (*Machinery*, London, vol. 47, no. 1209, Dec. 12, 1935, p. 312)

Lubrication of Modern Capstan and Turret Lathes

RECENTLY most manufacturers of medium and heavy machine tools have improved their oiling arrangements, for example, by providing more generous sumps. Automatic pump-fed lubrication has also been developed. On smaller machines oil-gun nipples have been adopted to make sure that oil will reach the surface for which it is intended with a minimum of trouble to the operator. Certain grades of oil

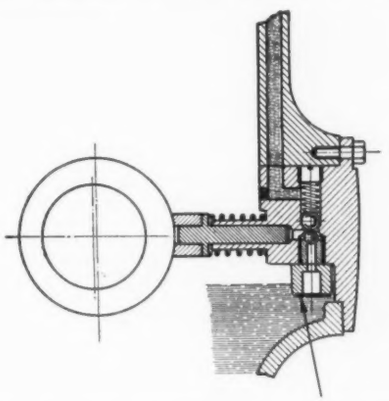


FIG. 5 CROSS SECTION OF CAM-OPERATED PLUNGER-TYPE PUMP

have a deleterious effect on metals; thus, tallow oil corrodes iron and copper; seal oil and rape oil corrode copper; while whale oil, lard oil, and sperm oil corrode lead.

It is also a notable fact that a mixture of these oils with, say, a mineral oil, does not negative the corrosive effect, and with this in mind it is important to remember that animal, vegetable, and fish oils are quite unsuitable for lubricating ball and roller bearings, ground gears, ground spline shafts, or any surface having a high-class finish.

As a typical example of the lubrication system on a modern machine tool, several illustrations of units of the Ward No. 7 combination turret lathe with covered bed are given. This machine is lubricated automatically by four simple pumps, a cross section of one of them being given in Fig. 5. This pump is of the cam-operated plunger type with a spring return of the plunger and even at slow speeds is a particularly efficient means of transferring oil from a sump to whatever part of the mechanism oil may be required. On all pumps the intake pipe is provided with a gauze filter to cleanse the oil being circulated.

In the Ward range of combination

turret lathes these pumps are used to lift oil from the sump to a reservoir in the topmost portion of the unit, from whence it is conducted to the required points by gravitation. In all machines the lower gears of the unit rotate in the sump so that both splash and gravitation are employed and the surplus oil pumped to the reservoir is allowed to cascade back to the sump.

On the latest type of machine the oil level in the sump is determined by the small compression-type tap in the external face of the pump itself. To bring the oil to the correct level this tap, *A*, Fig. 6, should be opened and oil poured into the filling hole *B* until it begins to exude from the tap, which should then be closed. The overflow pipe is provided to extract automatically any coolant which may find its way into the lubricating oil.

The lubricating system provides a supply of oil to the surfaces of the saddle which is in contact with the bed. It also serves the bearing surfaces of the cross-slide on the saddle. Oil supplied to these places is nonrecoverable, but the supply is graded to provide ample lubrication without undue loss.

The method of providing a constant film of oil on the sliding surfaces has two important results. In the first place the movement of the saddle and cross-slide are always easy to manipulate, thus reducing operator fatigue, and secondly, the oil film prevents metallic contact and thus reduces wear to a minimum.

Should it be necessary to dismantle the pump it can be withdrawn from the apron as a unit by the removal of the two hexagon-head screws by which it is held. (*British Machine Tool Engineering*, vol. 8, no. 96, November-December, 1935, pp. 423–428, 5 figs.)

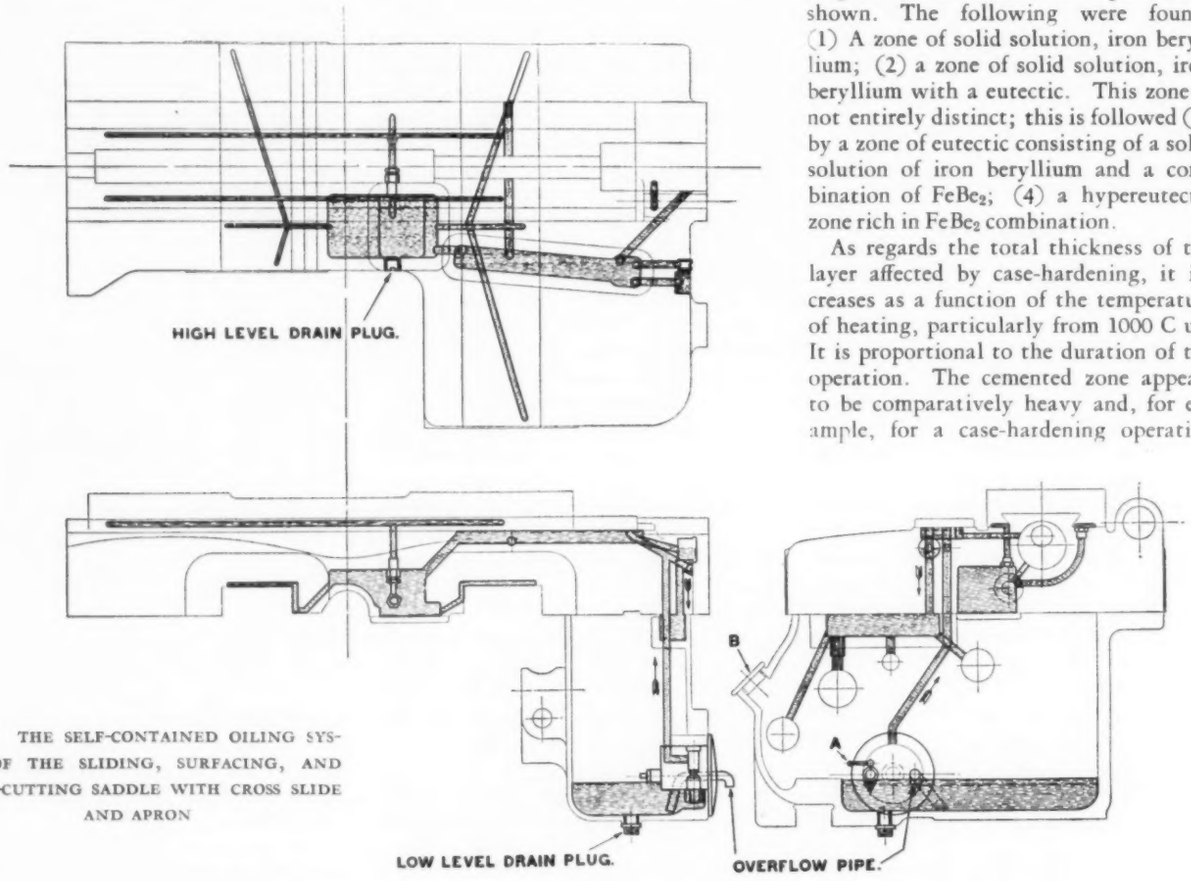


FIG. 6 THE SELF-CONTAINED OILING SYSTEM OF THE SLIDING, SURFACING, AND SCREW-CUTTING SADDLE WITH CROSS SLIDE AND APRON

METALLURGY

Case-Hardening of Iron and Iron Alloys by Beryllium

THIS is an extensive investigation and only some of the conclusions will be reported here.

After a brief historical survey of work on the subject of case-hardening by beryllium, the author presents several constitutional diagrams dealing with iron-beryllium, iron-boron, and iron-carbon alloys. From this he proceeds to the description of the experimental methods followed and the case-hardening of electrolytic iron by pure beryllium.

He comes to the following conclusions: The mechanism of diffusion is in strict accordance with the constitutional diagrams which have been previously shown. The following were found: (1) A zone of solid solution, iron beryllium; (2) a zone of solid solution, iron beryllium with a eutectic. This zone is not entirely distinct; this is followed (3) by a zone of eutectic consisting of a solid solution of iron beryllium and a combination of $FeBe_2$; (4) a hypereutectic zone rich in $FeBe_2$ combination.

As regards the total thickness of the layer affected by case-hardening, it increases as a function of the temperature of heating, particularly from 1000 C up. It is proportional to the duration of the operation. The cemented zone appears to be comparatively heavy and, for example, for a case-hardening operation carried on at 1100 C for 10 hr, the cemented zone has a thickness of 0.7 mm. The author considers next the influence of the presence of carbon and says that when ordinaty carbon steels are case-hardened by pure beryllium, the mechanism of diffusion is analogus to that observed with electrolytic iron, though more complex structures are found.

The following is a brief résumé of what has been found in this investigation as to the general properties of iron and iron alloys case-hardened by beryllium. The surface hardness of iron alloys is considerably increased by this process as shown by the following data. (The first figure is for the nontreated iron; the second, some material case-hardened at 1000 C; and the third, some material case-hardened at 1100 C, the hardness being in Brinell-Vickers units.) Electrolytic iron 138, 268, 318; soft steel (0.12 carbon) 176, 554, 628; medium hard

steel (0.36 carbon) 201, 733, 642; eutectic steel (carbon 0.09 per cent) 250, 1506, and 1267.

The following peculiar observation has been made. Beginning with 800 C the process of case-hardening is accompanied by a decarbonization process which appears in two forms from the surface inward, namely, a zone of complete decarbonization and a zone of progressive decarbonization. Beginning with a temperature of 900 C decarbonization decreases in importance and the cemented layer is composed of the several constituents previously referred to, namely, the zone of solid solution, the hypoeutectic zone, the eutectic zone, and the hypereutectic zone. (M. J. Laissus in *Revue de Métallurgie*, vol. 32, nos. 7, 8, and 9 July, August, and September, 1935, pp. 293–301, 351–360, and 401–422, 35 figs.)

POWER-PLANT ENGINEERING

Wind Power in the Antarctic

IN a paper before the British Association, E. Debenham said there was a natural resource in the air, which, however fantastic it might appear, might yet have a substantial interest for our descendants. It was a truism of science that we derive practically all our sources of power from the sun, either indirectly in the form of coal and oil, or directly in the form of water power, in which the sun by evaporation has raised water to a height from which gravity, suitably used, returns power to us. Although water is scarce in the polar regions, meteorological processes are doing the same for air, raising masses of air in one area which sink down in another, and so provide a source of power, less tangible, but just as real as that of water in a highland lake or reservoir.

The persistence, the strength, and the frequency of the Antarctic blizzards, according to Professor Debenham, suggest a vast source of power as yet untapped, and our descendants may yet make use of this power when coal is scarce and oil exhausted and all the water power in the temperate regions is fully harnessed.

He compared the power in the falls of Niagara, about 6000 tons of water falling per second, with the power in the little known Adélie Land, where an air river of at least some 50 miles in width and probably some hundreds of feet in depth is moving outward from the plateau at an average velocity of 50 mph or 70 fps for most of the year. (*The Fuel Economist*, vol. 11, no. 121, October, 1935, p. 1)

Senior "H"-Type Gilled-Tube Economizer

UNLESS the surface of the gills in the standard form of gilled-tube economizers is kept free from dust, the transfer of heat to the water is seriously impeded. Moreover, soot blowers are not entirely effective in cleaning the gills, while the steam jet cannot be directed against all parts of the heating surfaces of staggered tubes.

In the recently designed H-type of gill the gases pass through straight channels over smooth surfaces, these channels being uniform in area throughout the height of the economizer.

The tubes, which are $3^3/_4$ in. in internal diameter and $^1/_2$ in. thick, are made of special cast iron having a high tensile strength and resistance to corrosion. The sides which form the gas passages are cast integral with the tube and tangential to its periphery, and on these sides are cast fins spaced at about $1^1/_4$ in. centers. At the top and bottom of the cast tube between the sides are cast ribs which unite the two side plates and the center tube at these points. These ribs are placed opposite every fin and assist in transferring the heat to the walls of the tube.

At each end of the tube is cast a square flange with a circular raised face. These flanges support the tubes and also carry the connecting bends which are bolted on to them. The tubes are assembled in vertical lines, not staggered, and the gases flow in straight lines between the side plates and fins which form the walls of the gas passages.

The gases thus flow through a number of rectangular straight passages and their velocity at every point is uniform. A special soot blower has been developed to keep the heating surface of the economizer clean. The streams of steam blow directly through each gas passage and the jet of steam comes into contact with all the heating surface. A further development of the H-gill economizer is the Heenan twin-tube economizer and for the highest pressures the Senior superpressure economizer. (*The Fuel Economist*, vol. 11, no. 121, October, 1935, pp. 43–45, 4 figs.)

Replacing Plain Economizer Tubes by Gilled Tubes

IMPROVEMENTS obtained by replacing a plain-tube economizer by a gill-tube economizer and utilizing the space saved at the base of the chimney to form a flue-ash separator are referred to in *Archiv für Wärmewirtschaft* for August, 1935.

At a Ruhr coking plant, the flue gas from a number of fire-tube boilers and also some inclined-tube boilers, each with 360 sq m of heating surface, was passed through a plain-tube economizer with 1080 sq m of heating surface (Fig. 1 in the original article) with a chimney space of about 350 sq m. This economizer originally took the flue gas from four inclined-tube boilers, as well as from a number of fire-tube boilers, but later the gases were divided. This heated the total feedwater of the boiler plant by 30 C. The inclined-tube boilers were fired with low-grade unsalable coal, and notwithstanding a high chimney shaft, the surrounding neighborhood was subjected to a very considerable nuisance from the flue ash carried up the chimney. The fire-tube boilers were heated by the flue gases from the coke ovens.

The economizer has since been converted to a gill-tube type, which, together with the flue-ash separator, is illustrated in Fig. 2 in the original article. This latter has a heating surface of 2006 sq m; the depth of the tube groups in relation to the flue section is small, so that no considerable draft loss occurs. The housing of the old preheater has been converted into a flue-dust separator. The chimney floor has been formed into five collecting hoppers to take the flue dust which, at intervals, is drawn off into wagons at the bottom. The firm supplying the economizers guaranteed a preheating of the feedwater of 60 C, with a flow of 80 cu m of flue gas per hr at a temperature of 340 C, before the economizer, a temperature of the feedwater of not less than 68 C, and a draft loss not exceeding 9 mm of water column. In a test carried out by the Verein zur Uberwachung der Kraftwirtschaft of the Ruhr mines in Essen, the guaranteed values were exceeded for the heating of the feedwater, while the draft loss was under the guarantee. (*The Fuel Economist*, vol. 11, no. 121, October, 1935, p. 42)

SPECIAL MACHINERY

Crofts Electro-Mechanical Variable-Speed Gear Drive

THIS is an English production. The prime mover is a constant-speed motor running, let us say, at 720 rpm. It drives a constant-speed shaft of variable-speed gear by V-belt with a 2-to-1 reduction, and the speed gear has a 4-to-1 reduction range. The constant-speed

shaft runs at 360 rpm and the variable-speed shaft at any desired speed between 720 and 180 rpm. The final drive to the output shaft is through a 9-to-1 worm reduction gear, so that the final speed range is from 80 to 20 rpm. The actual speed of the driven machine is recorded by a tachometer, and the reversible motor operating the lever screw is controlled by a contact-type reversing starter actuated by a two-position push-button marked "speed up" and "speed down." The motor drives for as long as the button is pressed home and comes to rest when this is released. The degree of speed regulation is, therefore, very precise and positive. A slipping clutch and stop collars are provided on the operating screw in order to safeguard the speed-change gear from overrunning in either direction.

The original article also describes provision for stopping the driven machine without stopping the motor, and an interlock between the master switch and the main motor and the clutch lever so that the drive can only be stopped with the variable speed gear in the position giving the lowest speed to the driven machine. (*Engineering*, vol. 140, no. 3643, Nov. 8, 1935, p. 511, 1 fig.)

SPECIAL PROCESSES

Metallic Tubular Bellows

THESE metallic tubular bellows are extensively used and are manufactured in inside diameters from 0.35 to 3.75 in. and in lengths of from 1.2 to 2.3 in. for a movement of between 0.12 and 0.48 in. For higher pressures they are made with two or three walls. For sensitive apparatus which must respond to pressure variations down to 0.014 lb per sq in., very thin-walled bodies of external diameters ranging between 0.56 to 5.8 in. are supplied. On the other hand, larger seamless bellows, of as high as 12.4 in. outside diameter, have been made.

A special design is represented by steel bellows. These are produced, not by the formation of corrugations in a pipe, but by successive concentrically corrugated disks alternately welded together at the inner and outer edges, Fig. 7. The materials used for these bellows are alloy steels. The welding and heat-treatment of the seams is effected by a special process insuring absolute tightness and perfect joining of the component disks.

These steel compensation bodies are produced in inside diameters of from 2.4 to 16 in. Joining to the connecting elements, such as flanges, bottoms, and collars, is also effected by welding.

Contrary to the seamless bellows, the steel-disk bodies are able to stand high pressures and temperatures and to absorb considerable axial forces. They are used for compensators and noise dampers in pipe lines working at high pressures and temperatures, as, for instance, in

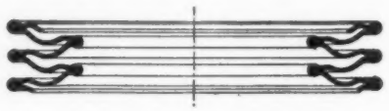


FIG. 7 COMPOUND STEEL BELLOWS

turbine and superheated-steam lines. In the capacity of elastic membranes they are employed in highly stressed regulating devices like pressure regulators and pressure reducers and in the place of stuffing boxes in bearings up to 16 in. in diameter, the use of a spring being dispensed with.

Finally, mention should be made of membrane bodies of this type used for highly sensitive regulating and measuring apparatus working with very slight pressures. Such bellows are made in inside diameters ranging between 0.4 and 4 in. and in wall thicknesses between 0.004 and 0.04 in. These compensation bodies, too, consist of concentrically corrugated steel disks combined by welding. Over the seamless bellows, they have the advantages of higher thermal stability, which enables them to withstand temperatures of up to 750 F and of extra high elasticity, a 2.4 by 1.6 in. bellows, for instance, permitting a movement of 0.4 in. at a pressure of 2.2 lb. (A. Klose in *Engineering Progress*, vol. 16, no. 11, November, 1935, pp. 272–274, 10 figs.)

Laminated-Wall Pressure Vessels

THE full value of the laminated construction for vessels to be used for high pressures has not been appreciated by users of pressure vessels until recently. The discovery of this value comes from testing solid thick-wall vessels to destruction in comparison with the testing of laminated thick-wall vessels to destruction. The value of laminated vessels can best be brought out by a description of their action under tests in comparison with thick solid-wall vessels.

The vessels tested were of 26 in. inside diameter and $3^1/_2$ in. thick which represented an average D/t value of about 8.4.

This D/t value has been taken to represent the relative stiffness of the vessels. The vessels composed of layer construction were each 19.25 in. inside diameter and had a wall thickness of 3.84 in. which represents an average D/t value of about 6.0, or a relative thickness greater than that of the solid-wall vessels. The vessels were designed with elliptical heads and reinforced openings, and were welded throughout with the most up-to-date welding procedure.

The solid-wall vessels failed at an average ratio of stress at failure to ultimate strength of the steel used in their construction of 79 per cent. The laminated vessels failed at an average ratio of 98 per cent. It is further believed that the difference between the action of the laminated vessel and the solid wall vessel will become less pronounced as the ratio of diameter to wall thickness is increased. However, the action of a vessel with thick solid walls is far different from that of the thick-wall laminated vessel in that the thick solid-wall vessel fails with a shattering effect and the laminated vessel opens up with much less violence. In the calculation of the maximum stress for the thick-wall vessel the Lamé formula was used, and in the calculation of the maximum stress for the laminated vessel the following formula was used:

$$S = \frac{P}{2t}\,\frac{(d_2 + d_1)}{2}$$

in which P is the bursting pressure; S the bursting stress; t the thickness of the vessel wall; d_1 the inside diameter; and d_2 the outside diameter.

These formulas are considered more nearly to represent the action of the respective construction methods used in the fabrication of the two types of vessel. The percentage difference, however, if only one formula is applied, is less than 2 per cent for the relative thicknesses and sizes tested.

The author attempts to explain why the laminated vessel is of superior performance. This is omitted because of lack of space.

There is one disadvantage in the laminated vessel which should be pointed out. If such a vessel should be used in a manner requiring the transfer of heat from the outside to the inside during operation, the rate at which heat can be transferred from the outside of the vessel to the inside will be lower than when using a solid-wall vessel. In all other cases, however, the laminated vessel will adjust itself with less serious effects to service operations than will the solid-wall vessel. (T. McLean Jasper, Director of Research, A. O. Smith Corp., Milwaukee, Wis. Abstract of paper presented at the

tenth annual meeting of the National Board of Boiler and Pressure Vessel Inspectors, abstracted through *Boiler Maker and Plate Fabricator*, Nov., 1935, pp. 319–320, 3 figs.)

TESTING AND MEASUREMENTS

Predicting the Strength of Structures From Tests of Plaster Models

THIS investigation was carried out in the Materials Testing Laboratory of the University of Wisconsin. The publication covers the matters of materials used for the model, technique of making and testing the models, and comparative tests of structures and models. (Raymond J. Roark and R. S. Hartenberg, Bulletin of the University of Wisconsin Engineering Experiment Station Series, No. 81, 1935, 51 pp., 6 figs.)

THERMODYNAMICS

i-s Diagram for Water Vapor up to 2800 C With Consideration of Dissociation

THE technical range of applications of hydrogen-oxygen combustion is extending in a direction which makes it necessary to investigate the thermodynamic processes at higher temperatures. All thermodynamic calculations may be simplified by the use of the *i-s* diagram for the respective materials. The purpose of this investigation is to design an *i-s* diagram for the important range up to 200 atm abs pressure and 2800 C temperature for water vapor as a product of combustion of hydrogen and oxygen. At the higher temperatures a considerable amount of dissociation takes place and this has to be taken into consideration.

The new *i-s* diagram for water vapor joins at 550 C the values established by Knoblauch and his collaborators, and in the range of higher temperatures comes up to the values of specific heats found by Schüle. One of the present authors, W. Pflaum, in a book published in Berlin in 1932, has established *i-s* diagrams for technical gases of combustion where the dissociation of water vapor and carbon dioxide has been considered and found to give the most appropriate values. (These values were obtained by tests with calorimeters.) The clearest and best foundation, however, is given by optical tests based on the quantum theory. The range between 550 and 2200 C has been interpolated, and it has been found that this can be done without any trouble by using the equations set up for the lower and upper ranges. In particular, for the range from 550 to 1200 C, the Hausen equation based on interpolated values of $(c_p)_0$ may be used in order to determine the c_p values at the higher pressures. A graphical interpolation, however, would have been too unreliable here.

It has been further noted that the Schüle values coincide with the interpolated values only from 2200 C up. Above 1400 C the true specific heats at different pressures are drawn as if they coincided. It is not certain whether more elaborate tests would show here any difference between those values.

HEAT CONTENT

However, even if above 1400 C the true specific heats c_p for different pressures coincide, certain differences occur in the average specific heats c_{pm}, because of the curvature of the c_p curves at the highest temperature (Fig. 1 in the original article, not reproduced because of the character of the original illustration). This average specific heat has been calculated from 0 C up, in order to make it possible to calculate the heat content i. The equation for it is

$$i = i'' + \int_{t_s}^{t} c_p dt + \int_0^{\alpha} W_p d\alpha$$
$$= i'' + c_{pm}(t - t_s) + \alpha W_{pm} \text{ [kcal/kg]} \quad \ldots\ldots [1]$$

Here the first member gives the heat content of dry saturated steam; the second the sensible heat of superheat; and the third the heat of dissociation.

As regards this heat of dissociation it is necessary to remember that the heat characteristic W_p is a function of the temperature. This is in accordance with the Kirchoff equation for the specific heats and is also true for the degree of dissociation α according to the van't Hoff equation (equilibrium constants of the law of mass action). These relations hold good only for water vapor and carbon dioxide and for their simultaneous presence in any gas of combustion.

The authors do not go into the complete discussion of the subject but say that it may be considered as established that for the constant of equilibrium K_{pw}, and for constant pressure in the cases of dissociation of water vapor as a function of degree of dissociation α_w it is found

$$K_{pw} = p \frac{\alpha^3_w}{(1 - \alpha_w)^2 (2 + \alpha_w)} \quad \ldots [2]$$

This as a function of absolute temperature gives

$$\log K_{pw} = -20.81 - \frac{22970}{T}$$
$$+ 8.28 \log T - 0.001\, T \ldots\ldots [3]$$

Equations [2] and [3] are in terms of 2 mols because of the equation of reaction

$$2H_2 + O_2 \rightleftarrows 2H_2O$$

In addition Equation [3] holds good for temperatures above 1200 C because, according to Fig. 2, in the original article, notable dissociation takes place only above that temperature.

Fig. 2 shows that at the higher temperatures there occur in the combustion of hydrogen and oxygen considerable amounts of vapor dissociation. Correspondingly, according to Equation [1], the lower temperature is attained for a given supply of heat. The ratio of latent heat of dissociation to sensible heat is, for example, as follows:

p =	1		10		100		atm abs
t =	2000	2800	2000	2800	2000	2800	C
$\alpha W_{pm}/c_{pm}(t - ts)$ =	4.5	21.4	2.4	10.8	0.7	4.8	per cent

Although side by side with dissociation of H_2O into $H_2 + {}^1/_2O_2$, there takes place also dissociation into $OH + {}^1/_2H_2$, and a further dissociation into $H + H$ takes place with a split-off of a hydrogen molecule, only the first of these dissociations can be considered as suitable for computation. Additional dissociations are here of secondary importance, but may be considered in part by means of the Schüle equations by a proper choice of specific heats.

ENTROPY

The values of entropy for the isobars can be computed from

$$\Delta s_p = \int_{i_1}^{i_2} \frac{di}{T} \quad \ldots\ldots [5]$$

They have been established by calculation for the range above the limit of saturation. Noting now the values of i and of s, the isobars and isotherms can be plotted on the *i-s* diagram. The isochors in the range of the high superheat can be computed from the equation of state

$$pv = RT = 47.1\,(1 + \alpha_w/2)T \ldots [6]$$

In the hitherto familiar low range of temperatures the values coincide with those obtained from the steam diagram. This is shown in the original article by Fig. 1 which cannot be reproduced for technical reasons. Fig. 1 is the new *i-s*

diagram and gives a reduced reproduction of the original diagram. The curvature of isotherms in the region of dissociation gives a visible expression of the influence of dissociation which increases with decreasing pressure and increasing temperatures. In the case of change of state through supply of heat, because of combustion of hydrogen and oxygen mixtures, which takes place at constant volume from t_{c0} to t_{s0} and which occurs after a certain maximum pressure has been reached and continues at that pressure to the end, the heat content varies according to the expression

$$\Delta i = \frac{H_u}{G_{\text{mixture}}} + AR\,(t_{s0} - t_{c0}) + \frac{\alpha_m}{2} AR\,(t_{s0} - t\alpha_c)\,[\text{kcal/kg}] \quad [7]$$

in which α_m is the average degree of dissociation which takes place between the temperatures $t\alpha_0$ and t_{s0} and has a value of 1200 C for temperature t_{c0}. The intermediate temperatures t_{c0} and t_{s0} represent approximate values since the *i-s* diagram refers only to one product of combustion, water vapor, while at these intermediary temperatures there is also present a mixture of burned and unburned material. This change of state therefore can be represented only approximately in the water-vapor diagram, while on the other hand, the end point of combustion corresponds sufficiently exactly to the actual state. (Walter Pflaum and Werner Schülz in *Forschung auf dem Gebiete des Ingenieurwesens*, Series A, vol. 4, no. 3, May/June, 1933, pp. 116–118, and one plate of diagrams)

VARIA

Windowless Office Building

THE Hershey Chocolate Corporation's three-story office building at Hershey, Pa., will provide scientifically produced artificial working conditions. The building is to have no windows and is to be completely standardized. It is said that the effect of actual daylight with none of its accompanying eye strain has been achieved through the installation of special lighting fixtures which combine features of Mazda and mercury-vapor lighting systems. In this way it is expected to secure a combination which will tone down the orange and red in the Mazda light by introducing a softening effect from violet and blue rays produced by the mercury-vapor lamp. (E. J. Berlet in *Power Plant Engineering*, vol. 39, December, 1935, p. 667)

WELDING

Weldability of High-Tensile Steels

THIS paper published by the National Advisory Committee for Aeronautics is based on a German publication. It surveys the development and present state of weldable materials suitable for airplane construction, and then proceeds to the difficulties encountered with the use of high-tensile steels.

Among the conclusions at which the author arrives is that a carbon content in excess of 0.25 to 0.3 per cent serves practically no useful purpose as far as strength is concerned. Higher carbonization made certain zones of the weld hard and others brittle. In tests made in 1928 steel tubing of 0.34 per cent carbon was still considered suitable for welding purposes in airplane design. Since then sheet of as high as 0.27 carbon and tubing of as high as 0.3 per cent and higher have been welded to fittings and lattices.

The two difficulties encountered are in the tendency of the weld to crack and in the weld hardness. The cracks tend to appear near the welded seam, usually at the joint between the bead and the welding work, at times extending even a few millimeters into a sheet and tubing. The striking fact is that such cracks can occur and still defy outside detection until the exposure of the bead by back-and-forth bending in the weld reveals them on a ferric-oxide film.

The conclusion at which the author arrives in regard to the tendency to cracking in welds is that it is a property locked up in the different steels in greatly varying degrees. Although its cause in special steels has not been completely established, one important result may be put down and that is the limit of phosphorous plus sulphur equals 0.07 per cent. This heretofore has been largely considered as adequate for welding steels but is not. The higher the welding strength (carbon content of an unalloyed steel), the lower the phosphorus plus sulphur content must be kept.

WELDING-CRACK TENDENCY

Judging from individual preliminary experiments, the hot- or cold-work condition appears to have no effect on the degree of crack tendency. Clamp welds of Cr-Mo steel, refined to 170,680 lb per sq in., revealed no increase over the soft annealed state with about 85,340 lb per sq in. tensile strength. Even a small cold draw of C and Cr-Mo steel tubes failed to intensify the hazard of cracks.

Cognizant of the danger of weld-cracking tendency, it is, obviously, the concern of everybody to forestall its occurrence on all vital welds. Aside from the burner adjustment, another chief cause noted was the coincidence of unfavorable material properties (lack of purity) with direct and, in totally unfavorable cases, indirect welding deformations due to clamping effect, faulty tacking, and heat distribution.

In a well-organized welding shop, the rules governing correct burner size, neutral flame adjustment, and slow cooling rate must be carefully and consistently enforced by the foreman and the metallurgist. Previously cited examples of T-joint and surface-flame test reveal that the indirect welding stresses, once they are known, can be easily avoided or at least minimized by correct tack welding, direction of welding, and flame adjustment, as, for example, by resorting to backward or right-hand welding. But the direct welding stresses are not always possible to avoid. Steel tubes in airplane construction, for example, are welded into lattices, where it is impossible to prevent the last welded piece from being subject to a regular clamp-weld condition. When large sheets are welded through a longitudinal seam to a plate, the first part of the welded seam after cooling, acts as a clamp for the subsequent seam portions. As the best test the author recommends the clamp weld.

WELD-HARDNESS

The second difficulty encountered in welding high-strength steel is weld-hardness, which means that the material in a zone modified by the welding heat becomes so hard and brittle as to cause trouble. It is said that the cause of this weld-hardness is primarily found in the fact that the composition of the steel, carbon, and manganese outside of the special alloying elements are almost always heavy contributors to the hardness effect. Weld-hardness and cracking tendency are not correlated, which means that weld-hard steel was not responsive to cracking, and vice versa.

Recommended test methods for determining whether and to what extent a steel is to be appraised as weld-hard, are: (1) Determination of hardness distribution next to a welded seam; (2) macro-etching of weld; (3) bending test of welding lugs of straps in the hardest zone, defined conformably to (1). (J. Mueller, *Luftfahrtforschung*, vol. 11, no. 4, Oct. 1, 1934, republished in English as Technical Memorandums of the National Advisory Committee for Aeronautics, no. 779, November, 1935, 28 pp., 12 figs.)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Turbine for Wheeler Dam

To the Editor:

The paper by Rogers and Sharp[1] discusses the Moody formula for stepping up hydraulic-turbine model efficiencies and the use of model tests for acceptance purposes. The authors present data concerning five propeller installations which show that in four of the five installations cited, the stepped-up efficiencies are slightly lower than the field-test values. The writer wishes to point out that it should not be inferred from these data that, in general, the Moody formula gives a conservative result. A group of field tests made by the Gibson method on Francis runners for which model-test data are available indicates that the stepped-up values of efficiency as determined by this formula are, as a rule, too high. The results for this group of tests covering 14 Francis runners are shown in Table 1 which shows that for this particular series the formula is too optimistic by 1.8 per cent on the average.

The paper does not seem to disclose that the determination of the maximum efficiency of the prototype is only one of several characteristics to be determined by testing. Usually, it is as desirable to know the location of the point of maximum efficiency as to know the value of the maximum efficiency. In the case of model testing it is frequently difficult to determine the exact location of the maximum-efficiency point as shown by Table 1. In the case of plant B of the table, the actual location of this point is 104 per cent of rated load, whereas the model test indicated it to be at 93 per cent. The limitations in the use of models for determining the main unit efficiency, both in respect to the absolute value of efficiency and the location of the maximum point, should be recognized by those resorting to this method of testing.

E. B. Strowger.[2]

To the Editor:

In a discussion of our paper, which you have called to our attention, Mr. Strowger states that the values shown in Table 2 of the original paper[1] should not be considered as showing that, in general, the Moody formula will give conservative results and he presents a table giving results of field tests made by the Gibson method on 14 Francis-type turbines compared to the model tests stepped up by the Moody formula. Mr. Strowger points out that the average of these 14 tests shows that the stepped-up efficiency is 1.8 per cent higher than the field results.

In another discussion of this paper, published in Mechanical Engineering, November, 1935, pages 728 to 730, S. Logan Kerr points out the importance of the accuracy of the laboratory tests and the established practice of determining the model efficiency to be used as a basis for predicting field performance. Table 1 of Mr. Kerr's discussion shows a study of 18 installations in which the model efficiencies stepped up by the Moody formula and the field results are compared. All of these model tests were made in the I. P. Morris laboratory, and in 17 of the 18 tests the variation is within 1 per cent. The average of all 18 tests shows that the field efficiency is 0.93 per cent higher than the model efficiency stepped up. This study of tests would indicate that, based on model tests made in the I. P. Morris laboratory, the Moody formula will give conservative results.

Mr. Strowger has stated to us that Table 1 of his discussion contains the results of model units made in various laboratories. It is noted that in the case of plants *D*, *F*, and *G* the efficiency of the model as shown is considerably higher than the efficiency of the large unit, which is contrary to all past experiences, as for the same setting the large units should certainly develop higher efficiencies. If, therefore, these three plants are eliminated from the table, the average of the 11 remaining plants shows that the stepped-up value of efficiency is 1.2 per cent higher than the field results.

TABLE 1 COMPARISON OF RESULTS OF MOODY FORMULA AND FIELD TESTS

		Model runner			Prototype				
Plant	Unit	Diam, in.	Max eff, per cent	Location of maximum eff, per cent rated load	Diam, in.	Max eff by field test, per cent	Location of maximum eff, per cent rated load	Max eff by Moody formula, per cent	Diff field test and formula
A	19	36	91.5	87	164.81	93.8	82	94.2	+0.4
B	21	41.5	92.3	93	176	93.8	104	94.6	+0.8
C	1	16.39	87.3	86	147.5	90.3	81	92.5	+2.2
D	2	36	93.0	99	136	89.5	95	95.0	+5.5
E	2	30	90.3	93	95.63	90.8	88	92.9	+2.1
F	3	37.25	93.3	90	108	91.0	87	94.9	+3.9
G	1	30.2	93.2	93	158	92.4	88	95.5	+3.1
H	3	15.75	87.0	92	194	90.4	89	93.1	+2.7
J	2	20	84.3	95	212	90.2	99	91.2	+1.0
K	9	20	84.3	95	212	90.9	99	91.2	+0.3
L	A	20	85.0	102	85	91.4	106	89.6	−1.8
M	11	15.88	86.2	102	212	90.0	95	92.8	+2.8
N	3, 6, 7	16.05	86.4	77	134	92.4	79	92.0	−0.4
O	1	15	90.1	86	107	91.2	77	93.9	+2.7
								Average difference	+1.8

[1] "45,000-Hp Propeller Turbine for Wheeler Dam," by F. H. Rogers and R. E. B. Sharp, Mechanical Engineering, August, 1935, pp. 499–506.

[2] Hydraulic Engineer, Buffalo, Niagara, and Eastern Power Corp., Buffalo, N. Y. Mem. A.S.M.E.

A comparison of these two studies indicates that if all the model tests are made in one laboratory the field results may be predicted by means of the Moody formula within close limits, but if the model tests are made in different laboratories, the prediction of the field results is liable to a somewhat greater discrepancy. This difficulty could be overcome, as suggested in Mr. Kerr's discussion, by having all laboratories calibrated on the same basis by testing the same model unit successively in each laboratory.

Mr. Strowger points out that it is also desirable to know the location of the point of maximum efficiency in the field, and that this is difficult to determine from the model tests. His table of installations shows that there is a considerable discrepancy in the location of the maximum efficiency in the field as compared to the location of maximum efficiency on the model. Our experience also indicates that in some cases this discrepancy in location of the maximum-efficiency point does occur. The most important reason is due to the model's not being truly homologous to the prototype. It is possible, however, to determine very closely the location of the point of maximum efficiency in the field without making a complete field test and measuring the flow. This can be done in the field by the use of two piezometers connected in the water passage at points where there is considerable variation in velocity such as the Winter-Kennedy piezometers. For this purpose, the square root of the difference between the piezometer readings can be considered as proportional to the quantity of water flowing. By reading the power output, the head, and these piezometers, a relative-efficiency curve can be drawn which will determine accurately the location of the point of maximum efficiency.

F. H. ROGERS.[3]
R. E. B. SHARP.[4]

Metallic Heat Insulation

TO THE EDITOR:

Mr. Nichols' paper[5] is timely because of the revived interest in metallic insulations. The value of metallic surfaces in reflecting radiant heat has been known since about 1850, and metal insulations have been used to a limited extent in Europe, a material known as Reflex Insulation having been tried in Germany a number of years ago.

Mr. Nichols gives results of tests on the sheet-steel insulation made by the cold-box method where measurements are made by melting of ice. It seems unfortunate that this method was adopted as it makes it difficult to compare these results with those of other investigators on the more generally accepted type of apparatus known as the guarded hot-plate apparatus, such as developed by the Bureau of Standards. There is always a question in the box method of test as to the correct "mean" area to use since the heat loss through the corners of the box cannot be readily integrated as can be done for two concentric cylindrical areas such as found in testing pipe insulation. The ice-melting method has generally been considered as containing too many variables to insure accurate results. If it is desired to test pipe insulation, at temperatures lower than ordinary room temperatures, it can be done by placing an electrically heated pipe apparatus in a cold room, the temperature of which is maintained by refrigeration. In the case of flat materials, the cold plate of the guarded hot-plate apparatus is water or brine cooled and thereby kept at a low temperature.

It is difficult to understand the results obtained on the 10-in. pipe apparatus as they are evidently too low, since the conductivity of 85 per cent magnesia is given as 0.27 at a mean temperature of 339.5 F. The true value of 85 per cent magnesia at this temperature is about 100 per cent greater, as shown by hundreds of tests by the McMillan laboratory, Mellon Institute, and others. It would be interesting to know if the pipe over the guard heaters was separated mechanically by means of an air space from the portion of the pipe over the test heater in addition to separating the heaters, which it is stated was done. Former tests with this type of apparatus have shown that consistent results are difficult to obtain even with the pipe separated and nearly impossible with a solid pipe.

Mr. Nichols states that it is apparent that most clean metals reflect sufficiently to use them for insulating purposes. This raises the question of just how effective the metals will be when they become oxidized or covered with dust, moisture, grease, soot, or other types of deposits which exist around many practical installations. Tests on the emissivities of oxidized iron and steel show an increase up to 1000 per cent over the bright metal. Aluminum surfaces, after deteriorating, often show increases in emissivity up to 1000 per cent as compared with a new material. It is, therefore, important in considering metallic insulation to know how long the metallic surface will remain in efficient condition. The difficulty of corrosion prevention in industrial and domestic applications of metals is well-known, and it would appear that adequate corrosion resisting alloys are still economically beyond consideration for metallic insulation. Some installations of metal foils in low-temperature equipment, in spite of every practical method of sealing the air spaces, have shown an accumulation of condensation. Professor Rowley found evidence of condensation in his tests of aluminum foil in an apparatus which supposedly was sealed better than in actual practice. Tests some years ago by Kratz, Day, and others at the University of Illinois showed that a layer of dust on a bright tin surface increased the emissivity considerably.

Since the entire effectiveness of metallic insulations depends upon the surfaces being clean, the question arises not only whether they will remain clean but whether in practical applications they will be clean when applied. Even though the metal sheets are furnished in perfect condition they could easily become dirty in shipping, in storage, or in application. Inspection and cleaning material on the job just before application would make application costs prohibitive.

Practical methods of sealing to prevent convection currents and infiltration of materials or gases which will affect the surfaces are believed difficult to construct. A complete seal which would eliminate these difficulties would increase the heat loss by conduction and offset to a great extent the advantage of the low emissivity of the metal surfaces. This would be particularly true if the seal were made of metal.

It would be interesting to know what type of separators were used in the metal pipe covering tested at 485 F since the wood or other types of separators mentioned would not be suitable and an asbestos material would be difficult to maintain tight against convection currents in various parts of the pipe covering. Also the question should be raised whether these spacers were included in the two-foot test section at all, and, if

[3] Chief Engineer, I. P. Morris Division, Baldwin-Southwark Corporation, Philadelphia, Pa. Mem. A.S.M.E.

[4] Hydraulic Engineer, I. P. Morris Division, Baldwin-Southwark Corporation, Philadelphia, Pa. Mem. A.S.M.E.

[5] "Metallic Heat Insulation," by J. T. Nichols, MECHANICAL ENGINEERING, October, 1935, pp. 621–624.

so, were they in the same proportion as they would be found in the finished pipe installation.

No mention has been made whether any means is provided in the construction of the pipe covering to take care of expansion. Unlike the usual forms of insulating materials the metal covering has a definite expansion, the amount of which depends upon the temperature of the individual layer. Because of the great difference in the temperature of the inner and outer layers and the resultant difference in expansion, it would appear that the covering would not remain tight, particularly after several periods of heating and cooling, such as occur when apparatus is operated intermittently. Such loosening of the layers, it would appear, would allow air infiltration and increased convection losses from the interior of the covering.

It would also be interesting to know how fittings in pipe lines are insulated with metal insulation without introducing an excess number of supports, which would increase the heat loss through the insulation.

R. C. PARLETT.[6]

TO THE EDITOR:

The Wien equation for intensity of monochromatic emission from a black body as used by Mr. Nichols[5] is believed to be open to the following criticism. First, the term in parentheses, as printed, is an exponent of e and not a multiplier as it appears to be. Second, the equation only on careful examination expresses the fact that the wave length of maximum intensity is a function of the single variable, temperature. It is upon differentiating the equation and setting $\frac{dI}{d\lambda}$ equal to zero that Wien arrived at his displacement law, $\lambda_{max} = CT$. Third, Wien's first equation poorly expresses the experimentally determined energy distribution. It has fallen into complete disuse since 1901 when Planck[7] published the equation

$$I_\lambda = C_1 \lambda^{-5} (e^{C_2/\lambda T} - 1)^{-1}$$

based on his new quantum theory, which fits experimental results closely.

In further analyzing the paper certain difficulties were encountered in following the calculations. The third paragraph of the paper presents calculated values of heat transfer across a series of five air spaces each $\frac{1}{2}$ in. in thickness. Conventional calculations for the structure and conditions as specified yielded a value of heat transferred by radiation of 12.8 as compared with that of 57.4 given by Mr. Nichols. In each the values are in Btu per hour per sq ft and are to be multiplied by the emissivity of steel. The stated value of heat transferred by conduction was found to be approximately correct. Convection need not be neglected, however, and a value for the transfer by both convection and conduction may be arrived at by subtracting the value for radiation from the total given by Rowley. Were the panel under consideration in a vertical position, the combined transfer by convection and conduction would be approximately 5.8 Btu per hr per sq ft across the series. Thus it may be seen that even though perfect reflecting surfaces were achieved, thereby entirely eliminating radiation, the heat flow would still be one-third of the total for all surfaces as full radiators.

In checking the calculations in Table 3 considerable variance was discovered. The data given were substituted in the usual formula for calculating the conductivity of cylindrical insulation with the results shown in Table 1. Some arithmetical error seems to be present in Mr. Nichols' second value in addition to the unaccounted-for values of the entire group. Further check on his apparatus seems advisable because the observed data yield results somewhat low. For example, the conductivity of ordinary 85 per cent magnesia is fairly well fixed by many investigators at about 0.53 Btu per hr per sq ft for a mean temperature of 350 F. Table 2 of Mr. Nichols' paper does not contain sufficient data for the purpose of recalculating the conductivities given.

An analysis of the temperatures of the outer surfaces of a sheet-steel pipe covering as compared with that for the conventional types shows that for the same pipe temperature and same heat loss, the former has the highest surface temperature. This means that for sheet-steel insulation greater dependence is placed on the resistance surface to air of the outer surface. It follows that this all-important outer surface will not remain efficient in all conditions. High convection losses due to drafts in addition to certain depreciation in surface efficiency due to dust, dirt, and corrosion will operate to the disadvantage of sheet-steel insulation. Also the higher surface temperature may often be undesirable in terms of increased fire hazard.

Mr. C. Libby, who presented the paper in Mr. Nichols' absence, stated that condensation of atmospheric moisture has occurred in connection with aluminum-foil home insulations to the extent of wetting the plaster on the inner side of the insulated wall. On the other hand he maintained that, though no reason was apparent, no condensation has ever been noted on sheet-steel insulation in any application so far made. Such a claim warrants careful attention. For example, domestic refrigerators operate with interiors at approximately 40 F while the surrounding air in summer may be at 100 F and have a relative humidity of 50 per cent for long periods. For such conditions the dew point is about 80 F and such air will be expected to condense moisture on any surface 80 F or cooler. If no condensation occurs it means one of three things: First, that no air filters in, requiring the construction to be absolutely hermetically sealed. Second, that no sheet-steel surface is 80 F or cooler, which means that at least two-thirds the temperature drop must be on the cold side of the sheet steel and hence that the steel accounts for only one-third the total insulation. Third, that moist air enters and dew-point conditions obtain but that no condensation occurs on the metal surface as would be expected. At no time did Mr. Libby maintain that perfect sealing was attempted or attained. If, therefore, he claims that the third alternative condition was the case, it would seem to controvert a vast mass of scientific

TABLE 1 DATA ON COVERING FOR 10-INCH PIPE

Insulation	Pipe temp, F t_1	Temp F, outer surface insulation t_2	Mean temp, F	$t_1 - t_2$	Input to 2 ft length, watts	Conductivity, k — Nichols	Conductivity, k — Recalculated	Difference per cent
4-sheet steel }	485	147	316	338	167	0.26	0.40	34.5
$^3/_8$-in. spaces }	475	161	318	314	172	0.26	0.44	41.0
85% magnesia }	597	146	372	451	238	0.28	0.42	34.0
$1^1/_2$ in. thick }	537	142	340	395	206	0.27	0.42	35.7

$$k = \frac{(\text{Watts} \times 3.415)(r_1 \log_e r_2/r_1)}{A(t_1 - t_2)} = \text{Btu per sq ft per hr per deg F per in.}$$

r_1 and r_2 = inside and outside radii of insulation in inches.
t_1 and t_2 = temperatures of inner and outer surfaces of insulation.
A = area of pipe, sq ft, maintained by watts input.

[6] R. C. Parlett, Mechanical Engineer, Johns-Manville Corp., New York, N. Y. Mem. A.S.M.E.

[7] "Über das Gesetz der Energieverteilung in Normalspectrum," by M. Planck, *Annalen der Physik*, vol. 4, 1901, p. 553.

and practical experience regarding moisture condensation and dew point, and so would seem to call for definite supporting evidence of a scientific nature.

Use of reflective-type insulation is a relatively new venture and much in the way of additional data is desired. Perhaps the greatest lack is in data regarding the durability of such materials. It is generally known that metals are oxidized at moderate temperatures and that as a result, their reflectivities may drop to a value as low as 5 per cent.

P. F. McDERMOTT.[8]
C. E. WEINLAND.[9]

Photoelastic Materials

TO THE EDITOR:

The writer is of the same opinion as Dr. Solakian in his paper[10] regarding the need for some new and better photoelastic material than that in common use today. As for marblette, it should be pointed out that the high value of the stress-optical coefficient is almost entirely offset for many kinds of work by the low values of its physical constants. When considered from the standpoint of a limiting deformation, marblette has very little advantage over bakelite. Merely to put the materials on a common basis bakelite would give 97 fringes at a deformation of 1 per cent while marblette would yield but 108 fringes for the same deformation. Rubber may be obtained which has a stress-optical coefficient of 60 to 70 times that of bakelite, but because of a low value for modulus of elasticity, only about 1 fringe would be found with 1 per cent deformation. The high creep rate reported for marblette is a distinct disadvantage.

The edge effect in bakelite is often noted much sooner than the author has reported. After only a few hours, the effect becomes noticeable. Is the effect one of oxidation, evaporation, or something else?

The writer has been looking for photoelastic materials by a trial-and-error method, which he chooses to call the "Edison" method. A study to determine the relation, if any, between the physical, chemical, and photoelastic properties would be valuable. This would probably lead to a study of the atomic structures of materials possessing the property of temporary double refraction. The writer is now making plans to start such a study.

F. G. SWITZER.[11]

TO THE EDITOR:

On page 767 of Dr. Solakian's paper[10] attention is called to the fact that "too great a thickness [of the photoelastic model] causes the principal stresses at a point to vary both in direction and intensity across the thickness of the plate," and it is stated that "such a phenomenon will render the experimental solution of the problem inaccurate." The writer thoroughly agrees with Dr. Solakian on this point, and feels that the possibilities of error from this cause have not been sufficiently emphasized in the past. As a proof of the existence of this effect in an extreme case a cantilever beam was loaded with a bending couple in its plane at its free end, and by a torsional couple (applied through a glass bar) midway of its length, as shown in Fig. 1. The bending couple gave a uniform bending moment, and plane stress, along the length of the beam, but where the torsional couple entered and disturbed the plane stress the photoelastic pattern was completely altered, as shown in Fig. 2. It should be noted that a torsional couple alone gives no photoelastic effect whatsoever.

In the author's Figs. 1 and 2 on page 768 are shown comparisons between bakelite and marblette under equal loads in which the photoelastic pattern in the marblette is considerably blurred in the regions of stress concentration, while the pattern in the bakelite is entirely clear at all points. This defective action in the marblette is undoubtedly due to its low elastic constants, mentioned by the author, and may in some cases be found to entirely outweigh the advantages of its high optical sensitivity. Part of the effect may be traced to the internal action of the third-dimensional stresses, already mentioned, while the remainder is due purely to surface refraction where the distortions of the originally flat surface of the model cause it to act as a lens. The writer has overcome the latter difficulty in many cases by placing a slip of flat glass over the distorted region and filling the intervening space with an oil of the proper optical density, both glass and oil being held in place by capillarity. Fig. 3 shows a celluloid specimen treated in this way. This specimen was so highly loaded that plastic deformation occurred in the weaker regions and the surface was severely distorted in consequence, but the pattern is entirely clear even in the plastic regions.

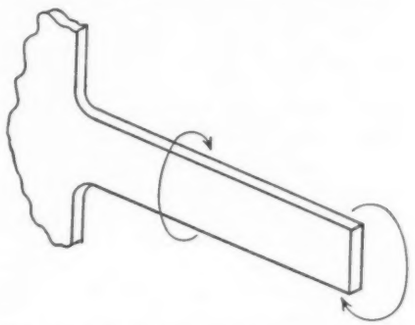


FIG. 1 CANTILEVER BEAM WITH BENDING AND TORSIONAL COUPLES

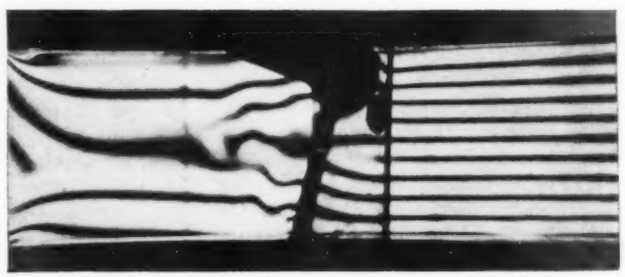


FIG. 2 CANTILEVER BEAM UNDER UNIFORM BENDING WITH TORSIONAL COUPLE APPLIED

FIG. 3 DEFORMED SPECIMEN WITH GLASS PLATES AND OIL TO ELIMINATE REFRACTION

The reported variations in the properties of bakelite (page 768) do not agree with the writer's experience. Not only have various determinations, made at the Massachusetts Institute of Technology over the period of a year, agreed among

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[9] Physicist, Johns-Manville Research Laboratories, Manville, N. J.

[10] "A New Photoelastic Material," by Arshag G. Solakian, MECHANICAL ENGINEERING, vol. 57, December, 1935, pp. 767–771.

[11] Professor of Hydraulic Engineering, College of Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

themselves within less than 2 per cent, but the stress-optical constant of 87.7 lb per in. of tensile load for one order of 5461 A light for the BT 61,893 bakelite used at M.I.T. may be compared with the figure of 43.9 lb per in. of shear load (87.7 lb per in. of tensile load) reported by M. M. Frocht, of Carnegie Institute of Technology. This almost exact agreement is probably accidental, but it does warrant the use of definite constants for the properties of this type of bakelite.

The absence of initial and aging stresses in marblette seems a great advantage both as regards the accuracy of research work and the life of models for repeated use in class work. Although these stresses in bakelite models are successfully removed by an annealing process used at M.I.T., their complete absence would eliminate the inconvenience and delay of the annealing.

Although the optical sensitivity of the marblette is considerably higher than that of bakelite, the lower "elastic" limit of the former limits the total number of interference orders available to a value only 34 per cent greater than for bakelite (using figures from the author's Tables 1 and 2). In addition, the presence of serious creep at moderate stresses (page 769) places a further limit on the availability of high orders of interference, and consequently the writer doubts if as great accuracy can be attained with marblette as with bakelite in the usual types of problems.

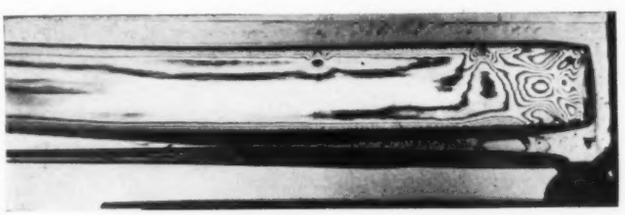

FIG. 4 LONGITUDINAL SECTION THROUGH "COLD-ROLLED" CELLULOID

In the use of marblette as an active surface layer over a three-dimensional metal model for the application of the method attributed to Mesnager, it should be noted that due to a low Young's modulus the marblette will not be highly stressed. Using figures from the author's tables, it is found that a stress of 30,000 lb per sq in. in steel would give only 250 lb per sq in. in a marblette surface layer. In ordinary photoelastic work at least five orders of interference are necessary for satisfactory accuracy at the point of maximum stress, and to obtain this a $^1/_4$-in. layer of the marblette would be required on steel. The writer has departed from Mesnager's suggestion of the use of a base model of high elastic constants, and is using models of celluloid and bakelite on which the active coating may be highly stressed, and consequently may be used in thin layers. The required reflection at the interface between the model and the coating is obtained by the use of an ordinary silvering solution on the model, followed by application of the coating.

Since this case is definitely not one of plane stress the resulting photoelastic pattern cannot be interpreted in the usual way, and may be entirely misleading. With very thin layers, however, the case approaches that of plane stress, and the stresses in certain regions may be determined in the usual way without appreciable error.

The attempt at determining torsional stresses (p. 771) is an interesting one, but since the stresses in this case are in the plane of the light rather than in a plane normal to the light path the writer is unable to interpret the resulting pattern numerically. With any type of double refraction the center of the bar would appear as a zero order of interference since it is a center of symmetry of stress, but the remaining interference effects must be due to some cause other than the "difference of the principal stresses," since there are no principal stresses in the plane of the cross section in the usual theory of torsion. It would be very interesting to hear from Dr. Solakian as to how he proposes to use this fringe pattern in evaluating the actual shear stresses imposed.

The application of photoelasticity to problems in plasticity, or "photoelasticity" (p. 771) is certainly valuable, and the high sensitivity of marblette combined with its apparent ductility should suit it to this work. To date the writer has used celluloid in this field with satisfactory results, as shown in Fig. 4, which is the pattern of residual stresses in a section cut longitudinally from a plate which had been "cold-rolled" in the usual type of mill. The high tensile stresses which machinists encounter in the surface of cold-rolled steel are closely duplicated in the celluloid.

R. W. VOSE.[12]

[12] Instructor in Photoelasticity, Massachusetts Institute of Technology, Cambridge, Mass. Jun. A.S.M.E.

TO THE EDITOR:

The advantages of marblette as a material for everyday tests are evident, and Dr. Solakian deserves credit for bringing the material to the attention of the profession and in giving the technical data for this material. It is of interest to note that Föppl and Neuber in Germany point out in their recent booklet on photoelasticity a plastic material of superior photoelastic properties, "Trolon," with a modulus of 300,000 lb per sq in. and elastic limit of 1600 lb per sq in., easily machined. It may be expected that this material has the same drawback as the marblette, i.e., that it flows more readily than bakelite. However, the ease of machining which is one of the characteristics of marblette offsets this disadvantage for ordinary work, where stress concentration is studied as an aid to machine design, and marblette will be rather welcomed by industrial engineering departments where photoelasticity is used as a tool.

GEO. B. KARELITZ.[13]

TO THE EDITOR:

F. G. Switzer's statement that "marblette has very little advantage over bakelite" is based on a wrong method of comparison. If a similar method of comparison based on "limiting deformation" were applied between glass and bakelite, the fallacy of the computed result would be evident. From the stress-strain curves of Fig. 3 of my paper an assumed strain of 0.01 per cent in glass and bakelite will be accompanied by corresponding stresses of 7000 and 750 lb per sq in., respectively, which in models of one inch thick, will produce about 6.0 fringes for glass and 11 fringes for bakelite. This would tend to prove that bakelite is only $^{11}/_6$ or 1.8 times optically more sensitive than glass, instead of 16.5 times, the exact value as given in Table 1 of my paper.

The blurring of the fringes in marblette in Fig. 2 of my paper has given rise to a statement that such a phenomenon will outweigh its other advantages in spite of the fact that an easy method of clarifying the blurred region is known to exist and is mentioned by R. W. Vose. On several occasions in the past I have emphasized the errors introduced by creep action and excessive lateral deformation in trying to produce in a stress pattern more fringes than actually necessary, namely, between 6 and 10. In spite of this fact, in the special case of

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Fig. 2 it was unavoidable to use a heavy pressure on the marblette plate for the sake of producing the minimum number of fringes in bakelite for purposes of comparison. In ordinary types of problems, marblette is practically free from blurring effect for fringe numbers as given, as seen from the accompanying Fig. 1, which has a ninth-order fringe at

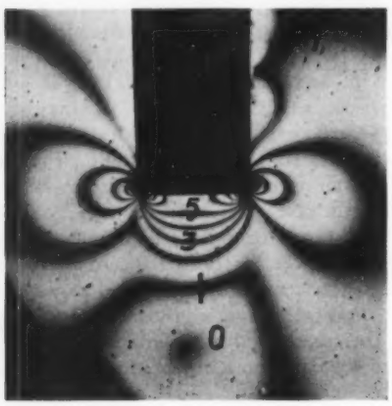

FIG. 1

the most stressed point. The method used by Mr. Vose to avoid blurring of fringes is easy and effective, except that it will leave unnecessary lines in the photograph corresponding to the edges of the glass plates. An improved method would be to introduce the model in a cell with glass walls containing a liquid of about the same index of refraction as the material of the model. I have tried such a method successfully in the study of stresses in models with nonparallel surfaces.[14]

The reported large variations in the properties of bakelite were obtained from tensile tests of specimens cut from various regions in a plate. Mr. Vose compares this against a maximum variation of 2 per cent in optical constants, which is probably accidental, as Frocht has also found large variations in the tensile strength of bakelite, a fact which would make the resulting value for the optical variations proportionally large. It is unnecessary to add that all synthetic materials are likely to show considerable variations in their physical constants, depending on many conditions.

The remarks made in reply to F. G. Switzer's discussion apply also to Mr. Vose's when the optical sensitivities of the materials are compared on a "limiting strain" or "limiting stress" basis.

Creep action exists in all synthetic materials. However, if sufficient time is allowed between the application of the load and photographing of the fringes (from 15 to 30 min for marblette), its effect will be harmless. Recent methods used by the author in heat-treating marblette have produced a product with an 80 per cent improvement in mechanical properties. The author believes that objections against the large creep in manufactured plates will be eliminated as soon as the test results with the heat-treated marblette are available for publication.

Before the fringe method of measuring stresses was applied, Coker's tension bar, the Soleil-Babinet quartz compensator and various other methods were and still are in use for measuring very small stress intensities or retardations amounting to a small fraction of the wave length. Surface stresses in a thin film of marblette coating on a polished metallic surface, no matter how small, should not, therefore, present any difficulty if it is a question of measurement alone.

The fringes in Fig. 7 of my paper are due to shear stresses alone produced from the permanent deformation after cooling the twisted bar, as I found no stress effect in similar disk sections cut from the original and heated (but not twisted) test bar. Elementary elastic theory[15] tells us that the shear stress τ at any point in a cylindrical bar of circular section under pure torsion is proportional to the angle of twist θ and the radial distance r of the point from the center of section. This shear stress acts in the plane of the section in a direction normal to the radius. At any point considered, the magnitude of τ is the largest of all the shear stresses acting in directions other than that normal to the radius, and hence τ will be a maximum principal stress σ_1. The radial shear stress being zero, it will correspond to the minimum principal stress σ_2; the difference $\sigma_1 - \sigma_2$ equals τ; and will be zero at the center of the section and increase proportionally with r toward the circumference, producing the fringe pattern of Fig. 7. The orientations of these stresses are found by the well-known isoclinic method, which, for the special case considered, is reported with other details, in another discussion.[16]

A. G. SOLAKIAN.[17]

[14] "The Scope of Photoelastic Analysis," by A. G. Solakian, *Product Engineering*, December, 1933.

[15] "Theory of Elasticity," by S. Timoshenko, McGraw-Hill Book Co., New York, N. Y., 1934, p. 220.

[16] Discussion of paper, "On the Hydrodynamic Analogy of Torsion," by J. P. Den Hartog and J. G. McGivern to be published in *Journal of Applied Mechanics*, Trans. A.S.M.E., March, 1936.

[17] Lecturer in Civil Engineering, Columbia University, New York, N. Y.

Creep of Steels

TO THE EDITOR:

A few comments may serve to emphasize the significance and importance of the discovery presented by L. L. Wyman in his recent paper.[18] In the first place "creep" is the term used by testing laboratories to describe the gradual distortion of material under the influence of prolonged stresses at high temperature.

It is extremely important to operators of high-speed machines, such as steam turbines, which have to stay in balance and which must avoid leakage in order to continue to give satisfactory service.

It may not be generally appreciated that the rate of distortion at high temperature increases as the fourth, fifth, or sixth power of the stress or even faster.

Thus if the creep strength of a material is only half as much, it will commonly creep as much as forty times as fast, and if its strength is only a third it may actually deform four hundred times as fast. The materials listed by Mr. Wyman vary three to one in creep strength.

To put it concretely, the material at the bottom of Wyman's list, taken from stock, actually distorted more in the first day than the special test bar it was intended to duplicate had distorted in its whole first year of test. Considering the fact that it was supposed to be of duplicate chemical composition and of closely similar physical characteristics, the importance of Wyman's discovery becomes more manifest.

It has been the fashion in the past to attribute discrepancies in creep-test results between different laboratories to lack of care in testing technique. More recent attempts to correlate data have been forced to conclude that the differences reported could not possibly be accounted for by test methods and must actually lie in some obscure characteristics in the material itself.

This paper describes one such characteristic that must be taken account of, particularly in the selection of material for manufacturing purposes to see that it is really as good as the samples used in test to represent its strength.

ERNEST L. ROBINSON.[19]

[18] "The Creep of Steels," by L. L. Wyman, MECHANICAL ENGINEERING, October, 1935, pp. 625–627.

[19] Turbine Engineering Department, General Electric Company, Schenectady, N. Y. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Hydroelectric Power Plants

HYDROTECHNICHESKIYE SILOVIYE USTANOVKI (Hydroelectric Power Plants). By I. B. Egiazaroff. Onti, Leningrad and Moscow, 1934 and 1935. Cloth, $5^3/_4 \times 8^5/_8$ in., Drawings and photographs. Vol. 1, third edition, revised and enlarged; 396 pp., 6 rubles. Vol. 2, second edition, revised and enlarged; 248 pp., 4.50 rubles.

REVIEWED BY I. GUTMANN[1]

AN important work on water-power engineering of great interest to power engineers is being evolved by Professor Egiazaroff, of Leningrad. The work is still in a state of flux characteristic of the present feverish activity in Russian technical education. Thus, the second volume in its second edition covers only about one-half of the material it had originally contained. The other half is to make up a third volume now in course of preparation.

In its scope the work is unlike any of the American or German standard texts on the subject. The first volume deals principally with the following subjects: (1) Statistical and graphical analyses of stream flow and its regulation by storage, including pumped storage; (2) characteristics of water wheels, their selection and operation to suit various conditions occurring in practice; (3) water-power economics, including discussions of the problems of hydroelectric vs. steam-electric power plants and the design and operation of plants utilizing both hydraulic and steam power which may resort to pumped storage as well. The second volume (second edition) is devoted to the design and operation of the headworks and intakes of high-head and low-head plants, with special reference to the control of ice and silt loads. The third volume will treat of the design and construction of power channels, including tunnels and penstocks, surge tanks, and the planning of power houses. The subject of dams is deliberately excluded, thus following the example of Etcheverry's treatise on irrigation engineering.

The work is eminently international in its character. In his presentation of both theory and practice, the author draws freely and wisely upon the research and experience of the whole world, without any semblance of provincial bias or diffidence. It may be observed that American engineering ranks high in a book of so cosmopolitan a character. The work of Weston Fuller, Allen Hazen, and Alden Foster, modified to suit the hydrological conditions of the Soviet Union, is the very backbone of the procedure of stream flow and storage analysis presented by the author. Adolph Meyer's evaporation studies are also featured. On the other hand the treatise summarizes a vast amount of western European and Russian work, some of it the author's original contribution, which should become known to American engineers.

Mathematical treatment and theoretical discussion are not overdone—in fact the book is quite American in these respects. It is also remarkably up to date.

Some of the controversial discussions, such as those on hydrographic analysis and silt control, for example, could be drastically condensed. More photographs, a detailed index, and classified bibliographic lists would enhance the usefulness of the book. An English translation of the definitive edition of this work would make a valuable addition to our literature on the subject.

[1] Associate Editor, Engineering Index, New York, N. Y.

Economics and Statistics

ECONOMIC ESSAYS IN HONOR OF WESLEY CLAIR MITCHELL. Columbia University Press, New York, N. Y., 1935. Cloth, 6 × 9 in., various tables, 519 pp., $4.25.

PRACTICAL APPLICATIONS OF THE PUNCHED CARD METHOD IN COLLEGES AND UNIVERSITIES, Edited by G. W. Baehne. Columbia University Press, New York, N. Y., 1935. Cloth, 7 × 10 in., 257 tables and figures, 442 pp., $4.50.

REVIEWED BY E. DILLON SMITH[2]

"ECONOMIC ESSAYS" consists of 17 timely and penetrating studies of business cycles and economic theory, each of which has been written by a competent and experienced person in the field under discussion.

Those who have contributed to this volume are: Asher Achinstein, Paul F. Brissenden, Arthur F. Burns, Paul H. Douglas, P. Sargant Florence, Abram L. Harris, Oswald W. Knauth, Simon Kuznets, Edward E. Lewis, Robert J. McFall, P. W. Martin, Frederick C. Mills, David J. Saposs, Horace Taylor, Dorothy Swaine Thomas, Willard L. Thorp, and Clark Warburton.

All of the contributors are former students of Prof. Wesley Clair Mitchell, distinguished economist of Columbia University. The essays were prepared as a tribute to Professor Mitchell on the occasion of his sixtieth birthday.

The essays of most importance to the engineer are on the relation between capital goods and finished products, low-rental housing, cycles in residential construction, urban decentralization, aspects of internal migrations, problem of overcapacity, purchasing power of the masses and business depressions, retail prices, and aspects of economic planning.

It is impossible to review within any reasonable space all of these essays, many of which deal with extremely complicated problems. In the essays considered as a whole there is no continuity of thought; their interests are wide and each is devoted to the field in which the author is a specialist. If there is a central theme, it is that a majority of the essays deal with the upheaval through which the international economy and the various national economies are passing.

Kuznets' essay, on the relation between the demand for finished products and the demand for capital goods, is based on the business-cycle theory formulated by J. M. Clark; i.e., the demand for capital goods is likely to move with the *rate of change* in the demand for finished products, rather than with the *absolute volume* of the latter. Under competitive conditions and the nonsubstitution of durable capital goods, Kuznets shows that:

(1) There is an inverse relation between entrepreneurs acting on demand for finished products and the size of the

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ratio of the stock of capital goods to volume of current output.

(2) The variation of demand for finished products tends to be positively related to oversupply of those durable capital goods whose ratio to their contribution to current output is high and whose relative share of costs in the finished products is low.

(3) Replacement demand must be substantial if the acceleration in the demand for finished products, as they are reflected in the demand for capital goods, is to take place continuously.

(4) Replacement demand is subject to variations of its own. For durable capital goods, the variations in replacement demand are partly a reflection of past buying of these goods, and partly a matter of obsolescence as a result of technological advancement. "But none of the factors makes for a direct correlation between the volume of the total demand for capital goods and the *rate of change* in the demand for finished products." These statements do not invalidate Clark's, but show that they are inadequate as a self-sufficient theory of cyclical fluctuations.

In the problem of distribution, Knauth, a director of R. H. Macy and Co., gives "Some Reflections on Retail Prices," and concludes that the relations are not at all fixed, but remarkably varied. "In one instance an offering of white curtains at a low price in the middle of February brought a demand for only 600 pairs; in the middle of March, the same curtains at the same price brought a demand for 11,000 pairs." Knauth concludes by saying that the dynamic relations between prices, demand, and the variations between different industries are so great that they are difficult of analysis, and tnat such complexity is scarcely appreciated by most merchants and producers.

The essays are valuable contributions to economic "science." They present, for the engineer, condensed arguments that he will generally accept—all in one volume rather than seventeen. Hence, the book deserves a wide reading by the engineer who is concerned with economics in theory and practice.

The book on the subject of the punched-card method is an interesting exposition of this method as it applies to colleges and universities, and since many of the problems that it deals with have their analogies in commerce and industry, it will be found valuable outside of the field for which it is primarily intended. Thus the engineer can advance his profession by capitalizing on others' efforts. For example, as outworn and tedious accounting programs of another day have become impractical and ineffectual, more efficient methods of control and cost analysis have become imperative; and with the Hollerith electric tabulating and accounting machines the arithmetical process, from statement to answer, is made mechanical and automatic.

The book deals with the most efficient and flexible use of such a machine, and therefore it interests only those who rent such equipment. But to these this book is an amazing and invaluable contribution. Of special interest are those sections on research analyses of data by the more complicated and refined statistical methods applicable to large samples.

This book indicates the possibilities of tabulating equipment as never before presented, with careful descriptions of the several procedures that are strikingly illustrated. For an office or laboratory possessing such equipment the book is indispensable.

Books Received in Library

AERONAUTICS, Twentieth Annual Report of the National Advisory Committee for Aeronautics, 1934, including Technical Reports Nos. 475 to 507. U. S. Government Printing Office, 1935. Cloth, 9 × 12 in., 649 pp., illus., diagrams, charts, tables, $2.75. This volume contains the general report of the activities of the Committee and its subcommittees, covering developments during the last fiscal year, and also includes thirty-three reports on a variety of fundamental researches in aeronautics which have been prepared during the year.

AUTOMOBILE ENGINEERING. Six volumes. Prepared by a staff of automotive experts under the supervision of Ray Kuns. American Technical Society, Chicago, 1936. Leather, 6 × 9 in., illus., diagrams, charts, tables, $24.80. Intended primarily as a home-study course, these volumes provide a detailed description of the construction, care, and repair of the automobile, and incidentally of the tractor, outboard motor, and motorcycle. The text is clear, definite, and profusely illustrated with photographs and drawings. All the current American makes of cars are included. The book is well adapted to the practical needs of the automobile mechanic.

BOOK OF THE AEROPLANE. By J. L. Pritchard. Longmans, Green & Co., London and New York, 1935. Cloth, 5 × 8 in., 254 pp., illus., diagrams, tables, $2.75. Captain Pritchard's book is intended to explain the modern airplane to the general reader. In clear, nontechnical language, he tells how it flies, how it is constructed and what it does. The early history of the airplane is outlined and space is given to famous flights and acres, to airplanes in war, to airways and other topics. This edition has been completely revised and enlarged.

BOOK OF A.S.T.M. TENTATIVE STANDARDS issued annually, 1935. American Society for Testing Materials, Philadelphia, Pa., 1935. Cloth and paper, 6 × 9 in., 1591 pp., illus., diagrams, charts, tables, cloth, $8, paper $7. The 1935 book contains 290 specifications, methods of testing, definitions, and recommended practices which have been proposed as standards, but not yet so adopted. Although still in the trial stage, they represent the latest thought of the committees on the subjects considered and find many applications in industry. Metals, ceramic and masonry materials, paints, petroleum, insulation, textiles, and other materials are discussed.

CYRUS HALL MCCORMICK: HARVEST, 1856–1884. By W. T. Hutchinson. D. Appleton-Century Co., New York and London, 1935. Cloth, 6 × 9 in., 793 pp., illus., $5. This volume completes Professor Hutchinson's life of the inventor and industrialist. It carries the history of the harvesting machine forward from 1855 to 1885, and also describes McCormick's other activities in philanthropy, politics, and business. The biography is a fully documentated account of the evolution of a great industry, of value to all students of business.

DIE BRENNKRAFTMASCHINEN 2. Gasmotoren. Gaserzeuger und Motoren für flüssige Brennstoffe. (Sammlung Göschen 1093.) By P. Meyer. Walter de Gruyter & Co., Berlin and Leipzig, 1935. Cloth, 4 × 6 in., 118 pp., diagrams, charts, 1.62 rm. The second volume of this elementary textbook is devoted to the generalities of gas and oil engines. A brief historical introduction is followed by a discussion of the uses of internal-combustion engines. After this a section is devoted to gas manufacture. The construction of gas and oil engines is then described, and a final chapter considers gas turbines.

DIESEL and Other Internal-Combustion Engines. By H. E. Degler. American Technical Society, Chicago, 1935. Cloth, 6 × 9 in., 237 pp., illus., diagrams, charts, tables, $2.50. This is a brief, practical account of the development of these engines, adapted to the needs of owners and operators. The principles underlying their operation, the construction and details of the various types, and data on performance are presented. Special attention is paid to Diesel engines. The book is a revision of an earlier one entitled "Internal-Combustion Engines."

DIESEL ENGINEERING HANDBOOK. Edited by L. H. Morrison. De luxe edition. Diesel Publications, Inc., New York, 1935. Leather, 6 × 9 in., 831 pp., illus., diagrams, charts, tables, $5. This handbook provides a great amount of practical up-to-date information on the operation and maintenance of Diesel engines, and is one of the best books available for the owner and operator. The information is clear and detailed and profusely illustrated with drawings. In addition to the general information, there are chapters on trucks, rail trains, locomotives, aircraft, and automatic Diesel-electric plants. The new edition shows great improvement over its predecessor, the text being rewritten and much expanded and the format much more convenient.

Eidgenössische Materialprüfungsanstalt an der E.T.H. in Zurich (Laboratoire Fédéral d'Essai des Matériaux Annexé à l'École Polytechnique Fédérale a Zurich). Bericht Nr. 86. FESTIGKEIT GESCHWEISSTER VERBINDUNGEN. By M. Ros and A. Eichinger. Zurich, Switzerland, 1935. Paper, 9 × 12 in., 28 pp., illus., diagrams, charts, tables. This report discusses the fatigue tests of welds carried out since 1927 at the Federal Materials Testing

Laboratory, Zurich. Upon the basis of test results, two methods are deduced, one precise and the other approximate, for computing the strength and deformation properties to be expected from a weld.

Eidgenössische Materialprüfungsanstalt an der E.T.H. in Zurich (Laboratorie Fédéral d'Essai des Matériaux Annexé à l'École Polytechnique Fédérale à Zurich). Bericht Nr. 94. I. VERHALTEN VON ETERNITROHREN GEGENÜBER VERSCHIEDENEN CHEMISCHEN AGENZIEN UND DIE EIGNUNG VON ETERNIT ALS MATERIAL FÜR ABZUGSROHRE VON GASVERBRAUCHS-APPARATEN. By P. Schläpfer. Zurich, Switz., 1935. Paper, 8 × 12 in., 11 pp., illus., tables. This study describes some investigations of the texture of cemented asbestos pipe, and the resistance of this pipe to attack by steam, water and sulphurous acid. Tests of the suitability of such pipe for the outlet pipes of gas retorts are also described.

Eidgenössiche Materialprüfungsanstalt an der E.T.H. in Zurich (Laboratoire Fédéral d'Essai des Matériaux Annexé à l'École Polytechnique Fédérale à Zurich). Bericht Nr. 96. DIE WÄRMETECHNICHEN GRUNDLAGEN DES OFENBETRIEBES, by P. Schläpfer. Zurich, Switzerland, 1935. Paper, 8 × 12 in., 22 pp., diagrams, charts. This essay discusses the physical and chemical processes that take place during the high-temperature distillation of coking coals, and the factors that influence the flow of heat in the charge. The importance of the coefficient of thermal diffusivity is investigated, and the influence of furnace efficiency on the economy of heat transmission is discussed.

ELECTRIC MELTING PRACTICE. By A. G. Robiette. J. B. Lippincott Co., Philadelphia, 1935. Leather, 6 × 9 in., 324 pp., illus., diagrams, charts, tables, $7.50. The electric furnace is here considered from the point of view of the practical metallurgist, who is offered a useful review of current practice in electric melting. Chapters are devoted to arc furnaces in the manufacture of steel; arc furnaces for melting iron and other metals; channel induction furnaces; coreless induction furnaces; resistor melting furnaces; and iron-smelting and ferro-alloy furnaces. Metallurgical practice is emphasized rather than plant construction. Representative costs are given frequently and there is a bibliography.

LA EVAPORACION EN LAS FÁBRICAS DE AZUCAR DE CAÑA Y REMOLACHA. By E. Koppeschaar. Norman Rodger, London, 1935. Cloth, 6 × 10 in., 124 pp., illus., diagrams, charts, tables, 7s 6d. ($2.00 in U. S.) This treatise discusses evaporation with special reference to sugar manufacture. The construction and operation of the various types of evaporators used in sugar mills are described, and the theory of evaporation outlined. Many practical data are tabulated. The author is a former director of the Vierverlaten sugar factory.

FESTIGKEITSBERECHNUNG ROTIERENDER SCHEIBEN. By I. Malkin. Julius Springer, Berlin, 1935. Paper, 6 × 10 in., 100 pp., diagrams, charts, tables, 10 rm. This monograph discusses the strength of rotating disks, with special reference to the problems of the steam-turbine designer. The various contributions on the question which have been made by the author and others since the appearance of the last edition of Stodola's "Steam and Gas Turbines" are incorporated into a single connected account, presenting the latest information on the subject.

Forschungsheft, 375. WÄRMEÜBERGANG AM SENKRECHTEN VERDAMPFERROHR, by E. Kirschbaum; DRUCKVERLUSTE UND BELASTUNGSGRENZEN VON FÜLLKÖRPERSÄULEN by E. Mach. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., 20 pp., illus., diagrams, charts, tables, 5 rm. The first of the two reports in this number describes an experimental study of heat transfer in vertical-boiler tubes. The second gives the results of a study of the pressure losses and load limits of packed columns for gas absorption.

GATES AND RISERS FOR CASTINGS. By P. Dwyer. Penton Publishing Co., Cleveland, Ohio, 1935. Leather, 6 × 9 in., 364 pp., charts, diagrams, tables, $3 plus $0.15 postage. This volume supplies a comprehensive discussion of the functions of gates and risers and a detailed description of their correct application. The treatment is a comprehensive one, covering practically all classes of castings. Gray-iron, brass, bronze, aluminum, steel, and malleable-iron castings are included. The material has appeared serially in *The Foundry*.

GRAVITY WARM-AIR HEATING, Digest of Research, Engineering Experiment Station, University of Illinois. Edited by J. D. Hoffman. Columbus, Ohio, National Warm-Air Heating and Air Conditioning Association, 1935. Edwin A. Scott Publishing Co. Cloth, 6 × 9 in., 516 pp., illus., diagrams, charts, tables, $2. For a period of sixteen years, beginning in 1918, the Engineering Experiment Station of the University of Illinois has been conducting an investigation of warm-air furnaces and furnace equipment, sponsored by the National Warm Air Heating and Air Conditioning Association. Much accurate technical information of value to designers and installers has been obtained through careful tests and distributed by various bulletins of the Station. The present work reproduces these bulletins in a single volume, rearranged in systematic form and accompanied by some editorial additions.

GRÜNDZUGE DER BERECHNUNG UND DES BAUES VON DAMPFTURBINEN. By E. Oehler. B. G. Teubner, Leipzig and Berlin, 1935. Paper, 6 × 10 in., 112 pp., illus., diagrams, charts, tables, 5.40 rm. A concise, practical introduction to the design of steam turbines. An introductory section presents the laws of thermodynamics and hydraulics which form the theoretical background. The remainder of the book discusses the design and construction of turbines and their elements, turbine regulation, and describes the types in use.

HIGH SPEED DIESEL ENGINES With Special Reference to Automobile and Aircraft Types. By A. W. Judge. Second edition. D. Van Nostrand Co., New York, 1935. Cloth, 6 × 9 in., 347 pp., illus., diagrams, charts, tables, $6. The theoretical and practical aspects of the high-speed compression-ignition engine are presented in this volume, which is intended as an elementary text for engineers and students. Special attention is given to the engine types adapted to automobiles and aircraft, with briefer discussion of stationary and railway types. The new edition has been revised thoroughly and several sections have been extended.

INTERNATIONAL ACETYLENE ASSOCIATION, Official Proceedings, Thirty-fifth Annual Convention, Wm. Penn Hotel, Pittsburgh, Pa., November 14–16, 1934. Published by the Association, New York, 1935. Cloth, 6 × 9 in., 290 pp., illus., diagrams, charts. The topics discussed at the convention were oxy-acetylene cutting, with particular reference to steel-mill applications; the metallurgical aspects of the oxyacetylene process; pipe welding and testing; welding in the transportation field; and education and safety in welding. The papers presented are included in this volume, together with committee reports and other business of the Association, a list of members, etc.

NEL CINQUANTENARIO DELLA SOCIETÀ EDISON, 1884–1934. (On the Fiftieth Anniversary of Società Edison.) By various authors. Società Edison, Milan, 1934. Four volumes. Vol. 1, 510 pp.; vol. 2, 487 pp.; vol. 3, 632 pp.; vol. 4, 318 pp. Cloth, 9 × 13 illus., diagrams, charts. In commemoration of its fiftieth anniversary, the Società Edison of Milan, the oldest electric public utility of Europe, has published this valuable review of the evolution of electric power during its lifetime. The first volume describes developments in water-power plants, steam and other prime movers, electrical machinery and transmission lines, the vital parts of the electric power plant. The second and third volumes discuss the general economic problems of the industry and its development in the different European countries, in Japan, and the United States. The final volume describes the economic development of Milan and contains a history of the Società Edison. The work is a valuable contribution to the history of engineering, and is published in an unusually attractive form.

POWER PLANT CHEMISTRY. By A. H. Gill. Fourth edition, revised. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 8 in., 228 pp., diagrams, charts, tables, $2.50. This volume presents the fundamentals of engine-room chemistry in a simple, practical manner. It is intended to give the engineman and boiler-room attendant a knowledge of the origin, properties, and uses of fuel, water and lubricants, and of simple methods of testing them. This edition has been revised and considerably extended.

REGELN FÜR DIE DURCHFLUSSMESSUNG MIT GENORMTEN DÜSEN UND BLENDEN, V.D.I. Durchflussmesserregeln. DIN 1952. Third edition. V.D.I. Verlag, Berlin, 1935. Paper, 8 × 12 in., 22 pp., diagrams, charts, tables, 5 rm. This pamphlet presents the revised rules of the German Standards Association for measurements of the flow of fluids by standard nozzles and diaphragms. Accompanying the rules are a discussion of the theoretical principles involved and additional information on the use of the rules, together with some examples.

TECHNISCHE THERMODYNAMIK, Part 1. (Wärmelehre und Wärmewirtschaft in Einzeldarstellungen, Bd. XI.) By Fr. Bosnjakovic. Theodor Steinkopff, Dresden and Leipzig, 1935. Paper, 6 × 9 in., 205 pp., diagrams, charts, tables, 13 rm.; bound, 14 rm. Professor Bosnjakovic's textbook is intended to supply a rigorous, but concise presentation of the essentials of engineering thermodynamics, in which mathematical aids are used sparingly. An exposition of classic thermodynamics, with emphasis upon the second law, introduces the subject, after which the engineering aspects of evaporation, flow, and refrigeration are discussed. A second volume is to appear.

ALEX D. BAILEY
Chicago, Ill., Group 6

JAMES H. HERRON
Cleveland, Ohio, Group 5

JOHN A. HUNTER
Boulder, Col., Group 7

PRESIDENT'S PAGE

IT IS obviously impossible for the President of The American Society of Mechanical Engineers to meet and talk personally with any large part of the members and so, with the assistance of the Editor in granting me this page, I propose to talk to the membership from time to time as things come to my mind that appear to be of particular interest.

If it were possible for me to talk personally with every Society member, or even with every local section and committee, many of the problems which now seem to plague us, because they are the results of misunderstanding, would disappear. Unfortunately, no president can undertake such a task, for there are 71 local sections, 115 student branches, and more than 200 committees, and the president is but a single individual.

In order to supplement my own personal contacts with members, sections, and student branches, the Council has authorized me to ask each of our seven vice-presidents to serve one of the seven geographical areas into which the country has been divided for purposes of local-section administration. These men expect to be called upon to meet with the groups in their areas and to act as special liaison officers between the members in these groups and the Council. Their responsibility is twofold: The actions and policies of the Council and the Society's administrative committees are to be interpreted by them to any group or individual that feels that some personal contact of this type will clear up misunderstandings or arouse interest and enthusiasm for the Society's work. Also they should bring to the Council, its officers, its administrative committees, and the headquarters staff the suggestions and criticisms of individuals and groups. Every one stands to gain by this arrangement.

But members, local sections, student branches, and other bodies have a responsibility also. I cannot expect the vice-presidents to assist me in this huge task of establishing personal contacts if individuals and groups do not call upon them for service. They await the invitation, and are willing to talk about the Society and answer questions, and they are also willing to listen to the suggestions and criticisms of members, and to help in so far as they can in local programs.

I hope every member, and at least every local section and student branch, will become acquainted with the regional vice-presidents. Their portraits are on this page. Get to know them, and let me serve you through them.

W. L. Batt.

EUGENE W. O'BRIEN
Atlanta, Ga., Group 4

ROBERT L. SACKETT
State College, Pa., Group 3

WILLIAM A. SHOUDY
New York, N. Y., Group 2

HARRY R. WESTCOTT
New Haven, Conn., Group 1

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

A FREQUENT contributor to these pages, and one whose technical and professional interests cover unusually broad fields, C. F. Hirshfeld, member A.S.M.E., and chief of research, Detroit Edison Company, gives his views this month on what many engineers will consider a highly controversial subject. It will be no surprise to those who know Mr. Hirshfeld to find him arguing for the affirmative on the question, "Should the engineering profession formulate a philosophy of social welfare?"

After reading of the difficulties Greville Bathe encountered in writing his recently published biography of Oliver Evans, presented in his paper in this issue, the reader gets some comprehension of the frustration and disappointment, as well as the exhilarating excitment and joy of success, in reconstructing the history of a too-long forgotten pioneer of engineering in the United States. Mr. Bathe is an Englishman by birth who was educated at the London Polytechnic Institute and who followed the profession of engineering as an engineer and machinery builder in that country prior to the World War. Coming to this country in 1919 he settled in Philadelphia where he was engaged in the manufacture of model machinery and inventor's models until he retired from active business in 1932. He has made engineering models for the Franklin Institute Museum in Philadelphia and other institutions. He is a member of numerous historical societies, including the Newcomen Society, to which the present paper was presented.

B. B. Talley, first lieutenant, Corps of Engineers, Wright Field, Dayton, Ohio, is the author of the article on "Aerial Photography." Lieutenant Talley received the degree of B.S. in electrical engineering from the Georgia School of Technology in 1925 and the following year served with the Westinghouse Electric & Manufacturing Co. He entered the Corps of Engineers, U. S. Army, in 1926 and was graduated from the Engineer School at Fort Humphreys, Va., in 1929. He was appointed to the Nicaragua Canal Survey where he was statloned until 1931 when he was assigned to topographic mapping of New York City. Since January, 1934, he has been engaged in research of equipment and methods for mapping by use of aerial photographs at Matériel Division, U. S. Army Air Corps at Wright Field.

Ford L. Prescott, senior mechanical engineer of the United States Air Corps, Matériel Division, Wright Field, writes on "Military Aircraft Engines of the Future." Mr. Prescott received the degree of B.S. in mechanical engineering from the University of Florida in 1923 and his M.E. degree in 1925. He served as instructor and associate professor at the university and later as construction engineer for the Southern Utilities Company at Palatka, Fla. Since 1929 Mr. Prescott has been in government service. In 1932 he was awarded the Maley memorial medal for meritorious contributions to aeronautical engineering. He is a member of the Society of Automotive Engineers, and the Institute of Aeronautical Sciences.

R. L. Templin, who presents a brief abstract of his paper "Aluminum Connecting Rods," is chief engineer of tests with the Aluminum Company of America. Mr. Templin holds the degrees of B.S. in civil engineering from the University of Kansas, of M.S. from the University of Illinois, and of M.E. from the University of Kansas. During the War he was in government service at the U. S. Bureau of Standards. Mr. Templin received the Dudley Medal in 1934 from the American Society for Testing Materials for his paper on "The Fatigue Properties of Light Metals and Alloys." He is a member of the American Society for Metals, the American Society of Civil Engineers, the American Society for Testing Materials, the Engineers' Society of Western Pennsylvania, Tau Beta Pi, and Sigma Xi.

Philip Drinker, of the department of Industrial Hygiene, Harvard University School of Public Health, who writes on protective respiratory equipment, was educated at Princeton and Lehigh. His work in industrial physiology at Harvard has been directed toward the study of gases, fumes, dusts, and their effect on workers. He is a specialist in ventilation and illumination, and a member of several scientific and engineering societies.

This month's review of economics literature from the Economics Department of the Massachusetts Institute of Technology, under the sponsorship of the A.S.M.E. Management Division is by Donald S. Tucker professor of economics in that department who has contributed previously to this series.

Report to A.S.M.E. Council on Professional Divisions

AS announced in the January, 1936, issue of Mechanical Engineering, page 39, the Committee on Professional Divisions submitted a report on a suggested reorganization of the Divisions to the Council of The American Society of Mechanical Engineers at its meeting of December 2, 1935. The report was referred by the Council to all interested groups for study and comment. The committee signing the report consists of W. A. Shoudy, chairman, Kenneth H. Condit, George B. Pegram, Crosby Field, L. K. Sillcox, and C. B. Peck, *Ex-Officio*.

The report recites the fact that it had been ordered by Council at the St. Louis meeting, October 11 and 12, 1935, and reviews the reasons and experiences that led the committee to feel that reorganization might be necessary. It also summarizes a discussion of certain criticisms of the divisions by W. H. Carrier.

WHAT IS A DIVISION?

Turning next to the question, What is a Division? the report says:

Neither the By-Laws nor the Rules definitely define a professional division. Article B-10 paragraph 1 of the By-Laws reads as follows:

The object of each professional division shall be to provide, through an organization of members of any or all grades particularly interested in a branch of engineering included in the scope of the Society's activities, means for promoting the arts and sciences of that branch.

Article R-10 of the Rules provides for an executive committee of five members, one member of which retires at the close of each Annual Meeting, and further provides that the new member shall be appointed by the president on recommendation of the Standing Committee on Professional Divisions. The control of the divisions is therefore directly in the hands of the Council and the president through recommendation by the standing committee.

Your committee believes it unwise to make any more rigid definition of a professional division or to restrict its activities any further. If criticism can be offered of the division's activities, it is due to inefficient supervision by the standing committee and the Council. Your committee believes that any such inefficiency is directly traceable to the rapid growth in number and size of the divisions. They have therefore made an analysis of member interest and offered a plan for better coordination which they expect will result in more efficient supervision.

Article B-10, Paragraph 7, of the By-Laws and Article R-10, Paragraphs 10, 11, and 12, of the Rules further provide for the organization of professional groups when the number of members interested is not sufficiently large to warrant the formulation of a professional division. The authority to organize such groups makes it possible theoretically to make provision for all possible professional specialties. However, the supervision of such groups requires almost as much attention as do divisions. Further, these groups have no place on the program, and no outlet for publication of their papers except through the willingness of a division to cooperate. The result is that some members do not receive adequate re-

turns from their membership and that in place of groups, committees of a division handle such problems, frequently with much overlapping of interests and effort. Later in this report your committee is making certain recommendations intended to remedy this condition.

PROFESSIONAL INTERESTS OF MEMBERS

There is then presented an analysis of a questionnaire designed to show the relative importance of the individual divisions. The figures are reproduced in Table 1. Commenting on the data of the table, the report states:

It is surprising that the first five divisions cover the chief interest of 73.53 per cent of the members, while the remaining ten divisions each represent less than five per cent. However, the total showing some interest is a better indication. On this basis nine show less than 18 per cent and five less than ten per cent interest. It is also interesting that the newest division, Process Industries, is fourth in member interest.

TABLE 1 ANALYSIS OF CHOICES OF PROFESSIONAL DIVISIONS INTEREST

(Based on about 65 per cent of the questionnaires received)

	First	Per cent	Second	Third	No Choice	Total	Per cent
Aeronautic	168	4.55	98	135	44	445	12.07
Applied Mechanics	327	8.88	375	301	122	1125	30.50
Fuels and Steam Power[1]	843	22.90	461	299	140	1743	47.40
Hydraulics	162	4.39	170	218	105	655	17.77
Iron and Steel	120	3.26	136	200	68	624	14.21
Machine Shop Practice	402	10.91	447	316	116	1281	34.78
Materials Handling	57	1.55	155	174	56	442	11.97
Management	800	21.70	509	361	158	1828	49.60
Oil and Gas Power	149	4.05	297	319	130	895	24.30
Petroleum	109	2.96	74	79	47	309	8.38
Graphic Arts	48	1.31	28	29	11	116	3.15
Process Industries	337	9.14	228	283	153	1001	27.20
Railroads	87	2.36	59	61	48	255	6.92
Textiles	44	1.20	41	36	16	137	3.72
Wood Industries	31	0.84	32	41	18	122	3.31
Total	3684	100.00	3110	2852	1232	10878	

[1] These two divisions are here combined, but were two separate items on the questionnaire.

RECOMMENDATIONS

Your committee believes that corrections of the evils mentioned can be effected best not by reorganization but by better coordination. They therefore recommend the following:

(1) That all divisions be grouped in five departments as follows: (*a*) Basic sciences, (*b*) power, (*c*) transportation, (*d*) manufacturing, (*e*) management; and that a department committee be constituted for each department to coordinate activities of the divisions and groups of the department and act as an executive committee for the department.

(2) That the chairman of each professional division be a member of the corresponding department committee.

(3) That the chairman of the department committee be a member of the Standing Committee on Professional Divisions, appointed by that committee as being the best qualified professionally to serve as chairman of that department committee; and further, that qualifications for the department committee chairmanship be taken into account in appointment to the standing committee.

(4) That the Standing Committee on Professional Divisions be encouraged to organize professional groups to cover fields not adequately covered and that these groups report direct to the appropriate department committee.

(5) That the professional groups be represented on the department executive committees, but without vote.

(6) That the Standing Committee on Professional Divisions be directed by the Council to review within the coming calendar year the activities and member interest of all divisions and to make recommendations to the Council as to those divisions which in the committee's opinion should be abandoned or changed to Professional Groups.

The standing committee does not recommend any change in the divisions' organization but rather would encourage all divisions to organize as many subcommittees as is necessary to properly cover their field. To this end they recommend a careful and detailed analysis by each division of its field, and as far as possible the preparation of a three- to five-year program.

On the basis of questionnaire returns your committee offers the following grouping of divisions into five departments (Table 2). There is given in this grouping the percentage of total member interest as shown by the questionnaire. There is also given in parentheses suggestions for professional groups that may be required properly to cover the field of mechanical engineering. These are for purposes of example and are not yet recommended. There will always occur questions or papers which can be assigned to more than one division. On such occasions the emphasis of the question should determine its classification.

TABLE 2 PROPOSED DEPARTMENT ORGANIZATION OF PROFESSIONAL DIVISIONS

	Percentage of membership	
	Chief interest	General interest
Basic Science Department	8.88	30.50
Applied Mechanics	8.88	30.50
(Mechanics of solids)	...	...
(Mechanics of fluids)	...	...
(Transformation of energy)	...	...
(Heat transfer)[1]	...	...
Power Department	31.34	89.47
Fuels and Steam Power	22.90	47.40
Oil and Gas Power	4.05	24.30
Hydraulic Power	4.39	17.77
(Industrial Power)	...	...
(Marine Power)	...	...
Transportation Department	7.91	18.99
Railroads	2.36	6.92
Aeronautic	4.55	12.07
(Highway or automotive)	...	...
(Passenger elevators)	...	...
Manufacturing Department	31.17	106.72
Machine Shop Practice	10.91	34.78
Process Industries	9.14	27.20
Iron and Steel	3.26	14.21
Petroleum	2.96	8.38
Materials Handling	1.55	11.97
Graphic Arts	1.31	3.15
Textiles	1.20	3.72
Wood Industries	0.84	3.31
Management Department	21.70	49.60
(Personal management)	...	...
(Equipment management)	...	...
(Cost management)	...	...

[1] Heat transfer is now a committee reporting to Process Industries.

Your committee asks approval of the foregoing recommendations in principle. We believe it would be desirable to submit this classification to the divisions representatives to work out details. For example, it is our thought that the Division of Applied Mechanics be developed into four divisions or groups as indicated by the parentheses (Table 2), and that a similar development can take place in the Management Division. Another suggestion is that the Hydraulics Division be called Hydraulic or Water Power, and that the science of hydraulics be included in mechanics of fluids.

RELATION TO OTHER STANDING COMMITTEES

Publications. The final selection or rejection of all papers should remain the responsibility of the Standing Committee on Publications. The first selection should be made by the divisions. For this purpose there should be organized an editorial committee for each department and no paper presented at a techni-

cal session should be printed without that committee's approval. However, with a publication budget which necessitates the rejection of many excellent papers, this editorial committee's task becomes that of comparing one paper with another and should include condensation of some papers to permit publishing a greater number. This selection or condensation cannot be done intelligently without some knowledge of budget limitations. It is requested, therefore, that the Committee on Publications set a budget for each department either in terms of pages or dollars.

Meetings and Program. With the above organization all space on annual or spring meeting programs should clear through the department executive committee, this committee in turn assigning time to the several divisions within the department. This procedure will do much to prevent overlapping of programs.

Local Sections. It is not expected that the creation of departments will in any way affect relations with this committee.

Research. Your committee believes that the organization of Divisions by Departments will permit a closer cooperation between the Standing Committee on Research and the divisions. Some confusion results from the fact that research is carried on by the divisions as well as by the standing committee. This is desirable, since division research is usually confined to practice. Better coordination is desired particularly as to presentation of reports at meetings and their publication. The place on the program should be secured through the department including the subject. The publication is the problem of that committee but no research paper should be printed within the department's budget allowance without that department's approval. Research papers originating without the department should have a separate budget provided by the Committee on Publications. Your committee recommends that the proper department or standing committee be informed of all research projects at their initiation.

Board of Technology. Relations will not be changed.

A.S.M.E. Nominating Committee Solicits Suggestions

THE 1936 Nominating Committee of The American Society of Mechanical Engineers, Prof. H. Diederichs, chairman, asks for suggestions of names of men qualified to fill the offices of President, Vice-President, and Manager of the Society. These names should be sent promptly to the chairman and secretary of the A.S.M.E. Nominating Committee so that they may be given thorough consideration prior to the national meeting of the Nominating Committee in Dallas, Texas, June 15 to 20, 1936.

The selection of Society officers is an important task, and the Nominating Committee asks the cooperation of the individual members of the Society in guiding its important deliberations.

Officers should be men of prominence and leadership, with time to devote to Society affairs. Previous service on committees and knowledge of Society affairs is a factor of importance. The president and vice-president must be of the member grade; managers may be of any grade of membership. Suggestions may be sent to the chairman of the Nominating Committee, Prof. H. Diederichs, Cornell University, Ithaca, N. Y., and to the secretary, Fred H. Dorner, 1107 East Knapp St., Milwaukee, Wis.

A.S.M.E. Meets in Dallas, June 15-20

THE Semi-Annual Meeting of The American Society of Mechanical Engineers at Dallas, Texas, the week of June 15, 1936, has been arranged in conjunction with the Texas Centennial Celebration. The celebration is being built around an exposition at Dallas upon which an expenditure of $15,000,000 is being made. Centennial Park, where the construction is well under way, covers 200 acres. Everything will be ready for the opening date, June 6.

The general theme of the exposition is historical in nature. The romantic history of the Lone State State and its progress and achievements will be stressed in all of the exhibits.

The A.S.M.E. program will provide for Council and Committee meetings on June 15 and 16, with technical sessions beginning June 17 and continuing through Friday, June 19. Saturday, June 20, has been set aside by the Exposition authorities as "A.S.M.E. Day," and tentative plans provide a public program with addresses by engineers of national prominence and the broadcasting of their remarks.

The technical program will include papers presented under the auspices of the Aeronautic, Process Industries, Machine Shop Practice, Textile, Railroad, Management, and Petroleum Divisions, as well as a number of papers developed by the North Texas Section on engineering enterprises of the Southwest. All local sections contiguous to the North Texas area are cooperating in developing papers for the program.

Entertainment will be provided which should prove attractive to visitors, especially for those coming from the North. Visits to the oil fields of eastern Texas, as well as to a number of plants in the neighborhood of Dallas and Fort Worth, are being arranged. The committee in charge of the meeting also wishes to know how many members are likely to be interested in visiting old Mexico after the meeting. The new Mexico National Highway from Laredo, Texas, to Mexico City will be completed in May. It is expected that many members may decide to drive to Dallas and then continue on the 1200 miles to Mexico City. On the other hand if as many as 100 persons decide to take the trip by train, arrangements can be made for a special train, the cost of round-trip transportation by train from San Antonio, hotel rooms, cat service, and some meals, being less than $100.

Members who have any thought of attending the meeting should notify the Secretary's office promptly. Thus it will be possible to make necessary hotel arrangements and develop other plans so that a choice of accommodations may be provided at regular rates. The headquarters hotel will be the Adolphus, Dallas, Texas.

Fred R. Low

FRED R. LOW, past-president, The American Society of Mechanical Engineers, an international figure in journalism and engineering, died Wednesday, Jan. 22, at his home, 256 Harrison St., Passaic, N. J., where he had been critically ill for several years. He was 75 years old.

A self-made man, whose formal schooling stopped when he was 14, due to severe illness, Mr. Low achieved wide recognition as an engineer and technical editor. At the time of his death, he was editor emeritus of the engineering journal *Power*, following 42 years (1888–1930) as its chief editor. He was a former Mayor of Passaic (N. J.), honorary member of the British Institution of Mechanical Engineers (Great Britain), and honorary doctor of

FRED R. LOW

engineering, Rensselaer Polytechnic Institute.

At the time of his death, Mr. Low was still chairman of two important committees of The American Society of Mechanical Engineers, dealing, respectively, with the codification of safety rules for the construction of steam boilers and unfired pressure vessels and the rules for testing boilers, turbines, engines, and other power equipment.

Mr. Low was an honorary member of the National Association of Practical Refrigerating Engineers and of the National Board of Boiler and Pressure Vessel Inspectors. He was a member of the National Association of Power Engineers, the Vereines Deutscher Ingenieure, the Newcomen Society, the Engineers' Club of New York, Yountakah Country Club (Nutley, N. J.), Plymouth (N. H.) Golf Club, and the Engineers' Club of Boston. He was past-president of the Passaic City Club.

Mr. Low was a 32nd Degree Mason and Shriner, a member of Passaic Lodge No. 67, F. & A. M., Centennial Chapter No. 34, R. A. M., Washington Commandery K. T. No. 21, Salaam Temple Mystic Shrine. He also belonged to B.P.O.E., Passaic No. 387.

Fred R. Low was born April 3, 1860, in Chelsea, Mass. He left grammer school in

1874 to become a clerk in a Western Union office, where he learned telegraphy and stenography. In 1880, after two years as a court and commercial stenographer, he went with the *Journal of Commerce* (Boston) as secretary to the editor, Thomas Pray. This paper carried a department devoted to technical problems of the textile-mill power plants. Mr. Low studied engineering in his spare time and became an intimate of the practical engineers, working with them on their technical problems. In 1886 he was made editor of the engineering department of the *Journal*.

During this period with the *Journal* he married Adeline Giles, September 24, 1881, whose algebraic problems he had labored over when she was a high-school student. He joined various engineering societies, made several power-plant inventions, and operated, in partnership with Frank M. Clark, a small company for their exploitation.

In 1888, Mr. Low left the *Journal of Commerce* for New York, to become the fifth editor of *Power*. This journal had been founded four years earlier, to serve the needs of power engineers in the operating field. Under Fred Low's leadership as editor, which extended 42 years, to 1930, the field of the magazine was broadened, without changing its practical approach, to serve also the needs of professionally trained power engineers, designers, and consultants.

From 1898 to 1906, Mr. Low published four technical books in the power field. In Passaic civic affairs, he was Councilman, 1901–1903, President of the Council, 1905–1906, and Mayor, 1908–1909.

The American Society of Mechanical Engineers elected him vice-president in 1918 and president in 1924. Other honors came to him in the latter year. Rensselaer Polytechnic Institute made him honorary doctor of engineering. On his visit to London, as The American Society of Mechanical Engineers' delegate to the World Power Conference, the Institution of Mechanical Engineers (Great Britain) awarded him honorary membership, there being at that time only 12 such members, including the late King George V.

In 1930, at the age of 70, Low became editor emeritus of *Power*. He continued to reside at Passaic, with periods spent at his farm in New Hampshire and fishing in Florida. He still maintained some contact with editorial and Society work, but this gradually diminished with failing health. Since 1931 he had largely been confined to bed.

Fred Low's career was outstanding as much for his personality and friendships as for his achievements in engineering and journalism. In his rise he never lost touch with the practical engine-room men of his early days. To them, as to his numerous friends among professional engineers, he was always "Fred." To them, as to him, the title "Doctor" was a superfluous appendage.[1]

[1] Prepared by P. W. Swain, editor, *Power*, and member, A.S.M.E. A committee, appointed to draft a memorial to Mr. Low consists of D. S. Jacobus, Geo. A. Orrok, and A. D. Blake. The memorial will appear in the Society Record, Transactions, A.S.M.E.—Editor.

A.S.M.E. Pacific-Coast Machine-Tool Meeting

THE San Francisco Section of The American Society of Mechanical Engineers is holding a Machine-Tool Meeting at the Engineers Club on the afternoon and evening of March 12. The program will be of special interest and is being arranged to coincide with a local exhibit of machine tools.

The American Engineering Council Plans Ahead

FOLLOWING the annual meeting of the Council, reported last month, and in line with the various actions taken by the delegates and the Executive Committee, President Potter and the staff of the American Engineering Council have reviewed the past activities of both committees and staff with the thought of giving a common sense of direction to both the delegates and the member organizations of the work for the year ahead.

The work of the Council is carried out first, through the agency of a paid staff at the Washington headquarters and second, by a group of committees, appointed annually by the president. Long-standing policies of the Council call for no new expression by committees, but the considered opinion of the members of the Council is developed through the year by its several committees and provides the basis for staff action.

COMMITTEE ORGANIZATION

Last year, the Committee on Public Affairs was organized in such a way that the chairmen of subcommittees on questions of public moment became in fact the general Committee on Public Affairs under the chairmanship of F. J. Chesterman. The intent of these committees is to establish principles for the staff handling of details; and so successful was this plan that it received much commendation at the annual meeting. This year the same thought has been carried into the organization of committees in the other fields of action of the Council and the following plan has received the approval of the Executive Committee:

The American Engineering Council committees have been divided into four groups:

(1) The Committees on Public Affairs, within which the following subcommittees have been set up: Aeronautics, public-works administration, relation of engineers in private practice to government, conservation and utilization of national resources, patents, surveys and maps, regional activities, and rural electrification.

(2) A second group of committees under a general chairman is entitled, "Committees on Engineering and Economic Surveys," under which the following subcommittees have been projected: The balancing of economic forces, and special studies.

(3) The third group of committees combines the activities of earlier major and subcommittees and has been called, "Committees on Programs for United Action of Member Organizations," under which the following subcommittees have been approved: Publicity for the profession, economic status, merit system in the public service, and survey of the engineering profession.

It will be observed that three new subcommittees have been established. The object of these committees is to seek to coordinate for a common sense of direction activities now being handled in some cases by special committees of member organizations. The committees of the Council are not to supplant the effective work of such committees, but rather to provide a common meeting ground for all those interested, with the object of securing a larger accomplishment through collective action, whenever this is practicable. These committees grow out of the expressed wish of one or more members of the Council to explore these fields for common action for the common good of the profession.

(4) The fourth group of committees constitutes the "American Engineering Council Operating Committees," and includes: The executive committee, finance, membership and representation, constitution and by-laws, and publicity for American Engineering Council.

From time to time, the activities of these various committees will be reported. In addition, it is proposed that the work of the Public Affairs Committee and of the state and local public-affairs committees will be coordinated and expedited by a special news letter made up in part of the present "Engineering Embassy Service" and restricted, as now, to a limited list of officers and committee members of member organizations.

ENGINEERING EXECUTIVES IN GOVERNMENT ADMINISTRATIVE DEPARTMENTS

Letters to the President of the United States and to the Secretary of the Interior have been written by President Potter, urging the appointment of an engineer executive of high standing, as Commissioner of the Bureau of Reclamation, a vacancy in the government service created by the sudden death of Dr. Elwood Mead. Assurances have been given that this post will be filled by a person of high capacity.

It should be made clear that the Council has presented this case, not on the basis of recommendation of any specific individual, but on the consistent principle that administrative positions in the government should not be filled by political appointees. It should further be stated that this action of the Council is not only in line with past policy of the Council, but upholds the principle of the merit system in public service.

In this connection, one of the most constructive thoughts expressed regarding efficient government administration on the occasion of the 53rd anniversary of the civil service, came from Harry B. Mitchell, president, Civil Service Commission of the United States. In substance he said that the determination of policy, "what the government shall do," is a separate function and should be placed in the hands of those officers who usually change after an election. On the other hand, he stated, competent administration demands continuity of service carried on by well-trained

employees who know what steps to take to put those policies into action.

MODIFICATION IN PROGRAMS OF EMERGENCY AGENCIES

Evidences accumulate that the policies advocated by the Council during the past year relative to the practical methods of expenditure under various emergency appropriations are gaining ground in Washington. As is well known, the staff of the Council under direction of its various committees has worked closely with the administrative agencies, with the hope of eliminating duplication of effort, providing for the consideration of past experience, the employment of competent engineering supervision, and other basic policies. The attempt has been made without the passing of resolutions, to aid the administrative agencies along these lines, in the public interest.

Natural forces of recovery are beginning to be felt and the trend is to take engineering work out of a "relief" concept and place it on the more normal business basis.

The chief engineer of the Works Progress Administration, for example, has been charged with the responsibility of reviewing all applications covering major construction and eliminating those unsuited to the work of the Works Progress Administration. These include the following six "sieves:"

1 Any construction project having a total estimated cost of $500,000 or more.

2 All building construction or reconstruction projects involving any single unit having a total estimated cost of $100,000 or more.

3 Water conservation, flood control, erosion prevention, parks, and other similar projects which contemplate the construction of one or more units, such as dams, swimming pools, or buildings which are estimated to cost $100,000 or more.

4 Projects for water-supply systems, sewerage systems, or sewage-disposal installations involving any plant or other single unit of construction costing $100,000 or more.

5 Projects for road construction estimated to cost $20,000 or more per mile or which involve any bridge, viaduct, or culvert estimated at $100,000 or more. Projects for landscaping, drainage, or other work along existing roads estimated to cost $10,000 or more per mile.

6 Projects for airports estimated to cost $200,000 or more, or which involve structures costing $100,000 or more.

The WPA Engineering Division is also instructed to determine:

(*a*) That the project is satisfactorily designed from an engineering standpoint, or that arrangements for satisfactory design have been made which will enable the project to be undertaken promptly.

(*b*) That the project is suitable for prosecution by force account.

(*c*) That the man-year cost is not excessive, considering the locality and the relief labor load to be taken care of in the state concerned.

(*d*) That the unit costs used in the estimates are reasonable.

(*e*) That the project can be carried on at a rate which make completion possible within the estimated time.

Every surface indication points toward the elimination of the Works Progress Administration from the larger construction activities, and possibly a radical improvement in the nature of future Emergency Public Works.

A.A.A.S. on Patent Procedure

AT THE St. Louis meeting of the American Association for the Advancement of Science held during the Christmas holidays, a resolution on the simplification of patent procedure was passed by the Council. After a fivefold "whereas" the resolution states:

1 This Council expresses the readiness of the scientific men of this country to aid in worthy moves to render the patent system of greatest benefit to the American public.

2 This Council endorses the recommendation of the Science Advisory Board that the processes of patent litigation be simplified, in order that expenses and delay may be reduced, by prompt, enlightened decision of patent cases by a single Court of Patent Appeals.

3 This Council endorses also the recommendation that adequate scientific and technical advice, on a high plane, be made available to this court and to all courts dealing with the intricate technical problems involved in modern patent cases.

4 This Council endorses the principle that the standard of invention should be raised, and recommends careful attention to this problem on the part of those charged with the administration of the Patent Office.

National Bureau of Engineering Registration

IN NOVEMBER, 1935, the National Council of State Boards of Engineering Examiners, of which T. Keith Legaré is executive secretary, issued a Bulletin of Information on the National Bureau of Engineering Registration.

The National Bureau of Engineering Registration is operated as a function of the National Council of State Boards of Engineering Examiners, with an Advisory Board of representatives from seven engineering societies. It was established primarily for the convenience of engineers, especially those practicing in more than one state, to minimize the effort and expense of securing legal registration. The Bureau also constitutes a clearing house for the convenience of the registration authorities of the various states having laws regulating the practice of professional engineering and acts as a reliable source of verified information regarding the professional records of engineers.

The Certificates of Qualification issued by the Bureau are in no sense obligatory for the applicant seeking registration in a state nor binding upon the state boards of registration, nor does the Bureau assume any responsibility to the applicant for securing his legal registration authorizing the practice of engineering in any state. The Constitution of the National Council and the registration laws of some states specially provide, however, for the acceptance of Certificates issued by the National Bureau of Engineering Registration.

MEMBERS OF THE COMMITTEE

Members of the Committee on the National Bureau of Engineering Registration, follow: Ralph J. Reed, chairman, representing Committee on Examinations, California (1938); Virgil M. Palmer, representing committee on E.C.P.D., New York (1937); G. M. Butler, representing Western Zone, Arizona (1937); Perry T. Ford, representing Central Zone, Ohio (1936); N. W. Dougherty, representing Southern Zone, Tennessee (1936); E. W. Saunders, representing Northeast Zone, Virginia (1938); and T. Keith Legaré, Executive Secretary, South Carolina.

The national engineering societies are cooperating with the National Council, assisting in the development of the usefulness and efficiency of the Bureau, through an advisory board on which the following representatives have been appointed: American Society of Civil Engineers, George T. Seabury; The American Society of Mechanical Engineers, James H. Herron; American Institute of Electrical Engineers, Walter I. Slitcher; American Institute of Chemical Engineers, J. C. Olsen; Society for Promotion of Engineering Education, R. I. Rees; American Railway Engineering Association, R. E. Warden; and American Association of Engineers, C. I. Ullrich.

REQUIREMENTS FOR CERTIFICATES OF QUALIFICATION

A certificate of qualification will be issued only to an applicant who fully complies with any one of the following requirements for a professional engineer and who conforms with other regulations of the Bureau:

(*a*) Graduation from an approved course in engineering of four years or more in a school or college approved by the Bureau as of satisfactory standing; and a specific record of an additional four years or more of active practice in engineering work of a character satisfactory to the Bureau, such as active practice, must indicate that the applicant is competent to be placed in responsible charge of important engineering work; or

(*b*) Successfully passing a written or written and oral examination designed to show knowledge and skill approximating that attained through graduation from an approved four-year course; and a specific record of eight years or more of active practice in engineering work of a character satisfactory to the Bureau; such active practice must indicate that the applicant is competent to be placed in responsible charge of important engineering work; or

(*c*) A specific record of twelve years or more of active practice in engineering work of a character satisfactory to the Bureau, which indicates that the applicant is qualified to design or to supervise construction of engineering works and has had responsible charge of important engineering work for at least five years, provided applicant is not less than 35 years of age.

FEES AND APPLICATION

The charges for services of the Registration Bureau are as follows: The fee for investigating and verifying the professional record of an engineer is $10, which fee must accompany application and will be retained by the Regis-

tration Bureau regardless of whether the results of the investigation warrant the issuance of a Certificate of Qualification or not.

When an application for a certificate or qualification is approved, the applicant will be so notified by the Bureau and upon payment by him of an additional fee of $3 the Bureau will furnish the applicant with a photostatic copy of his verified record, including Certificate of Qualification. Additional photostatic copies of verified professional records will be furnished at $3 each or two for $5. These certified copies can be sent direct by the Registration Bureau to state boards or other parties designated.

FURTHER INFORMATION

For further information, apply to T. Keith Legaré, executive secretary, P. O. Drawer 1404, Columbia, S. C.

Engineering Consolidation Discussed by E.I.C.

CONSOLIDATION of the engineering profession in Canada was advanced at the Annual General Meeting of the Engineering Institute of Canada in Hamilton, Ontario, on February 5, 1936. At the meeting, attended by representatives from the entire Dominion, a unanimous vote authorized negotiations looking to a realization of the hope that the corporate memberships of the eight associations of professional engineers in the provinces of Canada and the Engineering Institute of Canada may be identical.

The Engineering Institute of Canada includes in its membership engineers in the various fields. It has 25 branches from Vancouver to Halifax, possesses high standards for admission, and is the only national organization devoted to engineering. In all provinces of Canada except Prince Edward Island there are provincial organizations, authorized by law to select members qualified to practice in each province. In general, membership in these associations provides the license to practice, although the laws are not uniform throughout the Dominion. There are more than 2600 corporate members of the Institute and 3800 members of the provincial associations, a total of 6400, not taking duplication into account.

For fifteen years the Institute has discussed the problem of unifying and strengthening the profession on a Dominion basis and for some time there has been considerable sentiment in favor of the broad principle of consolidation. The recent action of the Institute was taken on a report of the result of a questionnaire to the Institute branches and provincial associations, the response to which nominally represented the views of 66 per cent of the total of 6400 mentioned. Large majorities indicated that the profession is in favor of consolidation and that, ultimately at least, the corporate memberships of the associations and the national body should be identical. It was also revealed that previous to the Hamilton meeting, in four provinces the associations and Institute Branches had initiated joint action looking toward consolidation and providing forums for discussion of the policies and procedures to be followed.

The Hamilton meeting approved the principle of consolidation and authorized conferences with the individual provincial associations and with the Dominion Council, which is made up of representatives of the eight provincial associations.

A Notable Gathering of Engineering Heads

THE growing importance of the engineer in public affairs and the necessity of calm, systematic thinking in politics and government were discussed analytically in a

ALL PRESIDENTS OF ENGINEERING SOCIETIES

(*Seated, left to right:* Admiral George H. Rock, president of the Society of Naval Architects and Marine Engineers; Arthur S. Tuttle, president of the American Society of Civil Engineers, and Edward B. Meyer, president of the American Institute of Electrical Engineers. *Standing, left to right:* G. M. Lovejoy, president of the American Institute of Mining and Metallurgical Engineers; Frederick D. Herbert, president of the Montclair Society of Engineers, and William L. Batt, president of The American Society of Mechanical Engineers.)

symposium "Ways That the Engineering Societies Can Serve" at a meeting of the Montclair Society of Engineers, Montclair, New Jersey, the evening of January 3, 1936.

This was a memorable occasion because after two years of effort, the heads of America's leading engineering societies were gathered at the one time and place, to contribute as spokesmen for their respective organizations their views on the changing conditions of society.

Beginning with an outline of the national progress of engineering education, it was agreed that the engineer can lend valuable aid to the management of public affairs whether municipal, county, state, or federal, and that where they have already taken such a part they have proved their worth in the reduction of extravagance in public funds. The inherent practice of the engineer to achieve a predetermined goal through only the most efficient means and not in the most direct manner was given as a quality which public management could well afford to emulate.

A.S.T.M. Committee Week Pittsburgh, March 2–6

UPWARD of twenty A.S.T.M. committees will hold meetings at the Hotel William Penn, Pittsburgh, during A.S.T.M. Committee Week, March 2–6, and a number of other committees are expected to participate. Many subgroups of main committees will also hold meetings and it is estimated close to 100 meetings will be held during the week. The various committees will review their research programs, existing standard specifications and tests in their jurisdiction and consider new specifications which are under development.

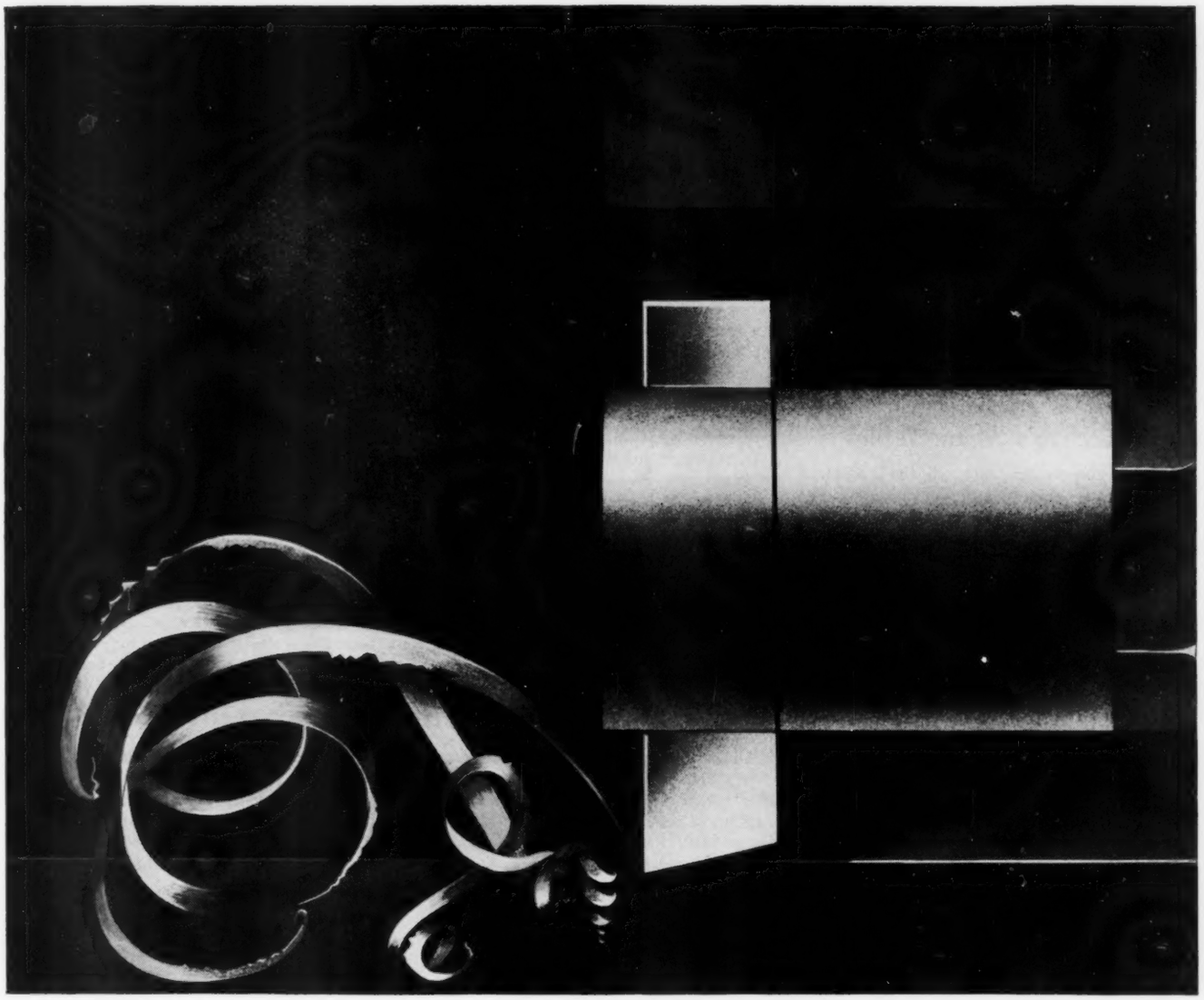
The technical feature of the Society's Regional Meeting to be held on Wednesday, March 6 in Pittsburgh is to be a Symposium on High-Strength Constructional Metals. The symposium will be held in two sessions, on the morning and afternoon of Wednesday, March 4. One will be devoted to papers on nonferrous metals and the other on steels. It is the intention not to consider metals and alloys used in the construction of machinery but chiefly those employed for such constructional applications as buildings, bridges, ships, automobile and railway car bodies, airplane wings, tanks, and the like. The papers will deal with chemical and physical properties, as well as manufacturing and fabricating properties, such, for example, as hot- and cold-working and welding. They will consider briefly and only where deemed essential, matters concerned with design stresses, construction economy, and the like.

A list of the papers to be presented, and their authors, follows:

Alloys of Copper, H. A. Bedworth, superintendent of service engineering, The American Brass Co.

Aluminum and Magnesium Alloys, E. H. Dix, Jr., chief metallurgist, Research Laboratories, Aluminum Company of America.

(*Continued on page 206*)



MOLY pares machining costs

MACHINE SHOP cost sheets often contain an accumulation of items that are avoidable. Some are caused by hold-overs from other processes — rolled-in scale — non-uniform hardness — distorted parts — meaning excessive tool, labor and material costs.

They are avoidable by standardizing on Molybdenum steels. Forgings are less likely to be scaly, seamed, or temper brittle. Carburized parts are less apt to be inconsistently distorted. High cutting speeds are safer and close tolerances more easily maintained. Time, power, labor, tool and material costs can be greatly reduced.

One maker of tool joints for oil-well service — a high-volume precision job — reports a 10% saving in over-all machine costs by standardizing on Chrome Moly steel (SAE 4140).

Your particular case may not be exactly similar, but — the savings in production costs effected by Moly steels and irons are not confined to the machine shop. So, it will pay you to investigate Moly in connection with your own problems. Our laboratory facilities are available if you are interested. Meantime our helpful technical book, "Molybdenum," is yours for the asking — as is also our periodically published news-sheet, "The Moly Matrix." Climax Molybdenum Company, 500 Fifth Avenue, New York.

CUTS COSTS CLIMAX Mo-lyb-den-um CREATES SALES

MOLY

Nickel and Its Alloys, A. J. Wadhams, The International Nickel Co.

Carbon and Low-Alloy Steels, E. F. Cone, editor, *Metals & Alloys*.

Corrosion-Resisting Steels, E. E. Thum, editor, *Metal Progress*.

A regional meeting dinner and evening entertainment will follow the afternoon session. All engineers interested in the subject of the symposium are invited to attend the symposium.

International Conference Table Changes to Be Applied to Keenan's Steam Tables

IN a reprinting, just off the press, of "Steam Tables and Mollier Diagram," by Joseph H. Keenan, published by The American Society of Mechanical Engineers, there has been incorporated Table 3(a), entitled "Changes Necessary to Agreement with Third International Conference Table." For the benefit of those who own copies of Keenan's tables, the new tabulation of values by which the enthalpies and entropies in the region above 300 lb per sq in. and 800 F may be brought into agreement with those resulting from the Third International Steam Tables Conference is reproduced herewith.

The Third International Steam Tables Conference, held in the United States in September, 1934, revised the skeleton tables which were published in the April, 1931, issue of MECHANICAL ENGINEERING, page 290. This revision was made possible by greater refinements in research that were carefully studied and discussed by the scientists and engineers participating in the Conference. Skeleton tables issued by the Third Conference were published in the November, 1935, issue of MECHANICAL ENGINEERING, pages 710–713.

However, the skeleton tables published in MECHANICAL ENGINEERING are in units not generally used by engineers in this country and not those used in the Keenan tables, and in order to be of value, conversion to English units is essential.

Table 3(a) published on this page, and incorporated in the recent printing of Keenan's tables, has been based on the skeleton table of 1935, but the values have been converted to the system of units used by Keenan and familiar to all engineers in this country.

To obtain value of enthalpy or total heat (h) and of entropy (s) conforming to the present international conferences, subtract the values given in the new Table 3(a) from the corresponding values given in Table 3 of Keenan's steam tables.

TABLE 3(a) CHANGES NECESSARY TO AGREEMENT WITH THE THIRD INTERNATIONAL CONFERENCE TABLE

Abs press,	Temperature—degrees Fahrenheit									
	800		850		900		950		1000	
lb/sq in.	h	s	h	s	h	s	h	s	h	s
300	2.2	0.0018	2.8	0.0022	3.2	0.0025	3.5	0.0027	4.2	0.0032
600	3.3	0.0027	4.0	0.0032	4.7	0.0037	5.6	0.0044	6.7	0.0052
900	3.8	0.0032	5.0	0.0041	6.2	0.0050	7.8	0.0061	9.4	0.0074
1200	4.1	0.0037	6.1	0.0051	8.2	0.0067	10.4	0.0082	12.5	0.0098
1500	4.1	0.0041	7.0	0.0062	10.2	0.0085	13.1	0.0105	15.7	0.0124
1800	4.0	0.0044	7.9	0.0073	12.1	0.0105	15.8	0.0130	18.7	0.0150

"Mechanical Processing of Cottonseed" Ready

THE recent publication of a "Manual of Mechanical Processing of Cottonseed" presents the results of an investigation in which A.S.M.E. Special Research Committee on Cottonseed Processing has been cooperating since 1932. The project was initiated in 1929 when the Tri-States Cotton Seed Oil Superintendents Association, with headquarters at Memphis, Tenn., requested the Engineering Extension Division and Engineering Experiment Station of the University of Tennessee to assist in the solution of some of the mechanical processing problems involved in the storage, treating, and expressing of oil from cottonseed.

The A.S.M.E. committee was formed to assist in the work as it related to mechanical processing and consisted of W. R. Woolrich, chairman, Homer Barnes, E. L. Carpenter, W. D. Edwards, C. E. Garner, and B. J. Sams. At the request of the committee two grants have been made by The Engineering Foundation for the conduct of the investigation, which has been carried on at the Engineering Experiment Station of the University of Tennessee, by which the manual has been published.

The complete report, which was prepared by Professors Woolrich and Carpenter, includes two chapters on the more important findings of the studies on mechanical processing and an extensive bibliography. The price of the volume, bound in cloth, is $2. Copies in paper covers are available at $1 per volume.

National Metal Congress, Cleveland, October 19–23

THE 1936 National Metal Congress and Exposition, to be held in Cleveland's Public Auditorium, under the sponsorship of the American Society for Metals, will be staged October 19 to 23, inclusive. The American Welding Society, the Wire Association, the Institute of Metals, and Iron and Steel divisions of the American Institute of Mining and Metallurgical Engineers are cooperating with the American Society for Metals.

Series of Public Lectures at Johns Hopkins

DURING March and April the School of Engineering of The Johns Hopkins University, Baltimore, Md., will conduct a series of public lectures on "Metals in Engineering Practice." The lectures will be delivered by A. G. Christie, F. W. Kouwenhoven, and L. M. Headley, of the department of mechanical engineering on March 4, 11, and 18, and April 1, 8, 15, and 22, at 8 p.m., Room 110, Maryland Hall, Homewood.

These lectures are open to the public and are intended for engineers, plant managers, foremen, and mechanics. They will cover the properties of important metals and alloys as used in the technical industries, and will develop the fundamental theory of alloys and the application of this theory to the preparation, selection, and usage of metals for industrial purposes, with particular reference to recent developments.

Leipzig Fair Dates Announced

THE Leipzig (Germany) Trade Fair will offer over 8000 exhibits gathered from 20 countries. The Merchandise Fair will be held from March 1 to 6, and the Engineering Fair from March 1 to 9, inclusive. The historic Fair will be larger than for several years past, three times the size of any prewar Fair.

Engineers Visit Corwith Plant

ON January 31, in company with representatives of the trade press and members of the American Society of Heating and Ventilating Engineers, J. B. Patterson, of the Midwest Office, Chicago, Ill., of The American Society of Mechanical Engineers, made a tour of inspection of the Corwith Plant of the Crane Co. in Chicago.

The Corwith plant, the largest of the Crane Co.'s plants, was begun in 1913 and commenced operation in the fall of 1915. The property covers 160 acres, 90 of which are occupied by 47 manufacturing buildings with a floor space of 72 acres. Approximately 30,000 products are manufactured at this plant.

A. C. Willard Honored

ARTHUR CUTTS WILLARD, member, A.S.M.E., President of the University of Illinois, received the F. Paul Anderson Gold Medal awarded by the American Society of Heating and Ventilating Engineers for distinguished scientific achievements in the field of heating, ventilating, and air-conditioning at the 42nd Annual Meeting of the Society, Chicago, January 29, 1936.

The F. Paul Anderson Medal Committee on Award for 1935 consisted of G. L. Larson, University of Wisconsin, Madison, Wis., H. P. Gant, Philadelphia, Pa., L. A. Harding, Buffalo, N. Y., S. R. Lewis, Chicago, Ill., and W. E. Stark, Cleveland, Ohio.

The F. Paul Anderson Award was created by Thornton Lewis, vice-president of the Carrier Corp., in honor of the late F. Paul Anderson, past-president of the American Society of Heating and Ventilating Engineers, former director of its Research Laboratory and former Dean of the College of Engineering, University of Kentucky, Lexington, Ky.

(*Continued on page 208*)

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C. F. Scott Honored

AT A MEETING of the Connecticut Society of Civil Engineers, Hartford, Conn., February 18, 1936, Charles F. Scott, professor of electrical engineering, emeritus, and member A.S.M.E., was made an honorary member of that society. Professor Scott was recently made chairman of the state board of registration to administer the newly passed engineers registration law in the State of Connecticut.

New York Safety Conference, March 3–5

THE Seventh Annual Greater New York Safety Conference will be held at the Astor Hotel, on Tuesday, Wednesday, and Thursday, March 3–5. Thirty-three complete half-day sessions will cover the entire field of accident prevention in industry, on the streets and highways, in the home, and in the air. All sessions are open to the public without cost.

Midwest Power Conference, Chicago, Ill. April 20–23

THE 1936 Midwest Power Engineering Conference will be held at the Palmer House, Chicago, Ill., April 20–23, 1936. Cooperating in the Conference are the Chicago Sections of several engineering societies, including The American Society of Mechanical Engineers, American Institute of Electrical Engineers, Edison Electric Institute, National Safety Council, American Society of Civil Engineers, American Society of Refrigerating Engineers, and the Western Society of Engineers. Representatives of the A.S.M.E. Chicago Section are A. E. Grunert and Ralph E. Turner.

Of the twelve sessions of the four-day meeting at which it is expected 35 papers will be presented, the A.S.M.E. Chicago Section is arranging for five. C. F. Hirshfeld is scheduled to speak on "Trends in Research," and Frank D. Chase, president of the Conference, will address the opening session on "Trends in Power."

Coming Meetings of A.S.M.E. Local Sections

Akron-Canton: March 26. Meeting at 7:30 p.m. Dinner at 6:30 p.m. at the Akron, Ohio Y.M.C.A. Building. Subject: Golden Gate Suspension Bridge (illustrated), by Capt. Charles M. Jones, bridge engineer of John A. Roebling's Sons Company.

Columbus: March 20. Faculty Club, Ohio State University at 6:00 p.m. Subject: Unity Begins at Home, by William L. Batt, President, The American Society of Mechanical Engineers.

Florida: April 3 and 4, morning and afternoon at Daytona Beach, Fla. (The program is not complete as we go to press.) This will be a joint meeting with the Florida Engineering Society, A.S.C.E. and A.I.E.E.

Knoxville: March 4. Meeting at the Hotel Johnson at 6:30 p.m. Subject: Unity Begins at Home, by President William L. Batt.

Schenectady: March 19. Edison Club, Schenectady. Subject: Municipal Sanitation, by Morris M. Cohn, sanitary engineer, City of Schenectady.

March 26. Edison Club, Schenectady. Junior Discussion Series.

Youngstown: March 23. Republic Rubber Club House, Albert Street, Youngstown, Ohio, at 8:00 p.m. Subject: The Mechanical Application of Rubber Products, by Carl H. Zieme, service engineer, Republic Rubber Company. Mr. Zieme's talk will be illustrated with slides.

Gear Manufacturers Meet in Philadelphia, April 20–21

THE Twentieth Annual Convention of the American Gear Manufacturers Association will be held at the Adelphia Hotel, Philadelphia, Pa., April 20 and 21.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after March 25, 1936, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

BEGGS, PHILIP B., San Francisco, Calif.
BRODER, SIMON, Washington, D. C.
DOUGHERTY, WILLIAM F., JR., New York, N. Y.
DREW, WALTER E., Jacksonville, Fla. (Rt)
DRYDEN, HUGH L., Washington, D. C.
DYER, WESLEY B., New York, N. Y.
FOLLARI, SALVATORE, Brooklyn, N. Y.
GARCIA, PEDRO, Golden, Colo.
HAUSMANN, LOUIS, Chicago, Ill.
HELMER, RICHARD LOUIS, Plainfield, N. J.
HILLE, EDWARD, Forest Hills, L. I., N. Y.
KRAKOWSKY, HENRY H., Bronx, N. Y.
LARSEN, ARILD F., Chicago, Ill. (Re)
LAUGHTON, WATSON B., Philadelphia, Pa.
LITTORIN, HARRY C., Elmont, L. I., N. Y.
MARIN, PROF. JOSEPH, New Brunswick, N. J.
MASCOTT, LUIS, Mexico, D. F.
MELE, THOMAS W., Baltimore, Md.
MOOSBRUGGER, JOSEPH, Baldwin, L. I., N. Y.
MORGAN, DALE R., Knoxville, Tenn.
ORCUTT, A. H., Handsworth, Birmingham, England
PEARSALL, H. S., San Francisco, Calif.
PEIX, C. H., Worcester, Mass.
PETERS, F. C., Palmerton, Pa. (Rt)
ROBERTS, ARTHUR, JR., Lynchburg, Va.
RUESS, MAX E., Milwaukee, Wis.
SCHRECKENBERGER, EDW., Brooklyn, N. Y.
SCHULZ, DONALD D., Scranton, Pa.
SCOTT, W. O. C., Vancouver, B. C.
SMILEY, EDWIN, Philadelphia, Pa. (Rt)
SMITH, JAMES JOSEPH, New York, N. Y.
STAPLES, FRANK C., Brooklyn, N. Y.
TABER, WALTER S., Honolulu, T. H.
TALAY, JOHN J., Lakewood, Ohio
TAYLOR, HENRY W., New York, N. Y.
WALKER, NORBERT JAS., Philadelphia, Pa. (Rt & T)
WHITE, L. R., Chatham, N. J. (Rt)
YOUNG, PROF. C. HIGBIE, New York, N. Y.

CHANGE OF GRADING

Transfer from Junior

BANTA, THEODORE C., East Chicago, Ind.
BLANCHARD, PHILIP D., Chicago, Ill.
FISCH, JACOB, York, Pa.
MERRICK, PROF. C. M., III, Easton, Pa.
STEFFAN, CHRISTIAN H., Glendale, L. I., N. Y.

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

BIBBINS, J. ROWLAND, January 27, 1936
COLLINS, FRED A., January 4, 1936
DIXON, JOHN ALFRED, January 13, 1936
DUBENDORF, JOHN H., January 17, 1936
HARTFORD, CLAUDE, February 4, 1936
HATCH, HENRY J., November 25, 1935
LOW, FRED R., January 22, 1936
LYNN, SCOTT, January 1, 1936
OLSEN, JOHN K., October 24, 1935
PIERCY, EDGAR, January 20, 1936
PULLUS, NICHOLAS J., January 31, 1936
SALMON, FREDERICK W., January 6, 1936
SEVIGNE, HENRI A., September 21, 1935
SWARTWOUT, EVERETT W., December 30, 1935
TREMAINE, E. G., December 25, 1935
WELLS, WARREN M., December 17, 1935

A.S.M.E. Transactions for February, 1936

THE February, 1936, issue of the Transactions of the A.S.M.E., contains the following papers:

Power Requirements and Mechanical Features of Textile-Printing Machines (TEX-58-1), by R. DeVere Hope

The Torque and Thrust of Small Drills Operating in Various Metals (RP-58-2), by O. W. Boston and W. W. Gilbert

Long-Time Creep Tests of 18 Cr 8 Ni Steel and 0.35 Per Cent Carbon Steel (RP-58-3), by H. C. Cross and F. B. Dahle

Short-Time Tensile Tests at 850 F of the 0.35 Per Cent Carbon Steel Material K2O (RP-58-4)

High-Temperature Properties of Cast and Wrought Carbon Steels From Large Valves for High-Temperature Service (RP-58-5), by H. C. Cross and F. B. Dahle

Cooperative Study of a Stable 18 Cr 8 Ni Steel Without Stabilizing Additions (RP-58-6)

DISCUSSION

On previously published papers by H. O. Croft and C. F. Schmarje; H. A. S. Howarth; J. E. Mulligan; S. W. Spielvogel and S. Kameros; J. M. Mousson; E. G. Young and C. P. Pei; E. S. Cole; and W. M. White and W. J. Rheingans.

For closing dates on discussion, see footnote on first page of each paper.